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FIFTY-FIFTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

PART I.

REPORT OF THE PRESIDENT AND OTHER OFFICERS OF ADMINISTRATION FOR FISCAL YEAR ENDED NOVEMBER 30, 1917.

FEBRUARY, 1918.

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MAR 30 1920

The Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Dec. 1, 1917.

To His Excellency SAMUEL W. McCALL.

SIR: — On behalf of the trustees of the Massachusetts Agricultural College I have the honor to transmit herewith, to Your Excellency and the Honorable Council, Part I. of the fifty-fifth annual report of the trustees, for the fiscal year ended Nov. 30, 1917, this being the report of the president of the college and other officers of administration to the corporation.

I am, very respectfully, your obedient servant,

KENYON L. BUTTERFIELD,
President.

REPORT OF THE PRESIDENT OF THE COLLEGE.

Gentlemen of the Corporation.

I herewith submit my annual report as president of the Massachusetts Agricultural College, and with it transmit reports from the other administrative officers of the institution.

The past year has been a notable one for the college for at least two reasons. It has witnessed the completion of fifty years of service by the institution, and it has seen the second half century of its history ushered in by an eager response to the call to the colors, as our country entered the war. Indeed, the war soon became the chief concern of all persons connected with the college. The fact that the college has always had a military establishment led, of course, to a keen personal interest in the war on the part of students and younger alumni who might be eligible to military service. The prompt announcement in Washington that agriculture and the development of an adequate food supply was a prime concern in the war added another reason for intense interest. There is therefore but one subject this year suitable for the customary discussion in which it has become a habit to indulge in my annual report, and that is

THE MASSACHUSETTS AGRICULTURAL COLLEGE AND THE WAR.

On Feb. 9, 1917, the Governor appointed 100 men as a Committee on Public Safety. In the personnel of the committee and in its original subcommittees no place was made for agriculture; evidently the military aspect of the war problem was uppermost in the minds of those responsible for the plan. I immediately corresponded with Mr. James J. Storrow, the chairman of the committee, with reference to the importance of recognizing food supply as a war emergency, with the result that he requested the Massachusetts Federation for Rural Progress to name a committee on food production and conservation.

This action was taken on March 2, and the committee was at once made a subcommittee of the Committee on Public Safety, and on March 5 had organized with Mr. John D. Willard, who had been "loaned" by the Franklin County Farm Bureau, as executive secretary. The personnel of the committee was as follows: —

Kenyon L. Butterfield, *Chairman.*
Philip R. Allen.
Reginald W. Bird.
Nathaniel I. Bowditch.
Joshua L. Brooks.
Carlton D. Richardson.
Henry Sterling.
Marcus L. Urann.
Wilfrid Wheeler.
John D. Willard, *Secretary.*

The program of food production adopted by the committee outlined three sources of increased production, — the first and chief, on farms, largely with the staple crops; the second, in boys' and girls' gardens; and the third, through family gardens carried on by residents of cities and villages. Later an auxiliary committee on food conservation was organized, with Dean Arnold of Simmons College as chairman.

The First Steps.

The program that was adopted by this committee and the methods of work put into operation were largely those that had been formulated by Director Hurd, assisted by members of the staff with whom he had counseled individually and in conference.

The college at once placed itself practically at the disposal of the Commonwealth as represented in the Committee on Public Safety, stating that it wished to render every possible service in the emergency. Steps were immediately taken to mobilize the institution fully, as will appear as the report proceeds. Our attitude towards both State and national government is shown by the following vote of the faculty: —

> *Whereas,* The land grant colleges of America, owing their origin to the stern realization of the absolute need and utter unpreparedness of the nation during the darkest period of the great strife, were established in order that the nation might ever be ready to meet victoriously any and every foe that might oppose her at any time during the long future; and

Whereas, To these colleges during all the years since the Morrill Land Grant Act the people of the United States and of the Commonwealth have given generously of their substance and wealth, and ever manifested unfailing loyalty and love to them; and

Whereas, The Massachusetts Agricultural College, as one of the members of this noble sisterhood of colleges, has been bountifully nurtured and blessed by the rare munificence of the government; be it therefore

Resolved, That we, the faculty of the Massachusetts Agricultural College, fully recognizing our peculiar obligations to our beloved country in this hour of her new danger and peril, do pledge anew to her and to her cause our outmost loyalty and devotion, and place at her service without reservation all the strength, influence and resources which God hath vouchsafed to us; and be it further

Resolved, That a copy of this resolution be forwarded to the President of the United States, and to the Governor of this Commonwealth, and that it be placed before the people as the true attitude of the faculty of the Massachusetts Agricultural College.

Campus Mobilization.

A committee on campus mobilization was organized March 5, with the following personnel: Professor Hurd, Dr. Brooks, Professor Sears and Professor Lockwood. This committee immediately started a census of students and alumni with reference to their fitness for, and willingness to perform, either military or agricultural service. The committee also canvassed the entire faculty, and made assignments to different lines of work in accordance with a definite schedule. The committee also acted as a clearing house for students and faculty in agricultural work, approving projects, starting work and assigning members of the staff to special pieces of work as occasion demanded.

The members of the extension staff, of course, carried on their regular work, but in a highly augmented fashion. Their service was performed very largely in co-operation with the county farm bureaus, which soon became the actual centers of operation through the State. Many of the teaching staff, as soon as they were relieved from their regular duties, took up assigned special war service in the field or on the campus. The research work of the experiment station naturally went on about as usual, inasmuch as all this work is concerned with problems of food production.

The Students in War Time.

Acting in accordance with expressions coming from President Wilson, Secretary of War Baker and others, as well as in accordance with our own convictions, every endeavor was made, after war was declared, to keep the teaching work going in normal fashion. It soon developed, however, that not only were the students very uneasy and inclined to neglect class work, but the demand for farm labor in the State was such that their help was greatly needed. As a consequence, the faculty passed a vote on April 20 providing that students who wished to leave before the end of the year to work on farms would receive credit for their work in college if they performed satisfactory farm labor for twelve weeks. Under this plan the large majority of the students left within two weeks, and by the 1st of May the college was practically closed.

Nearly all of the students going into agriculture found their own positions, although the committee on mobilization assisted in many cases. Nearly 400 men found employment in farming, gardening or in supervision of such enterprises as boys' and girls' clubs, community garden plots, etc. About 50 of the men went into military service, so that all told nearly 500 students, or about 95 per cent., were performing war emergency service by the 1st of June, 85 per cent. being in agricultural service and 10 per cent. in military service. This is a remarkable record. Every effort was made to keep in touch with the students in the field. Many of them were visited personally during the summer by members of the staff. Reports came in from the students as well as from their employers. Dean Lewis devoted a large part of the summer to studying these reports, corresponding with both students and employers. Many men who had never before had farm experience soon adapted themselves to the work, and the testimony of employers was uniformly most complimentary to the men.

The year opened with a greatly reduced attendance. Out of 138 men registered in the class of 1918 last fall only 64 returned to college this autumn. In the class of 1919 the attendance is 113 this fall as against 174 registered in the fall of 1916; 117 men out of 170 in the class of 1920 returned this autumn. This year there are 118 freshmen as compared with a registration of 170 last year.

Students now in Military Service.

The number of students in military service December 1 is indicated in the following table: —

CLASS.	Commissioned Officers.	Others.	Total.	Per Cent. of Class.	Overseas.
Sophomores,	–	16	16	10	6
Juniors,	3	28	31	15	4
Seniors,	21	45	66	40	11
	24	89	113	–	21

Graduate Students.

In 1916 the enrollment of graduate students was 57. The maximum registration in the fall of 1917 was 29, approximately one-third of whom have since left. This decrease of 60 per cent. in the enrollment of graduate students is undoubtedly due to the war.

The Alumni.

The alumni have responded to the call to military service in the same spirit as have the students. The following table of records will indicate our latest information on this point: —

CLASS.	Commissioned Officers.	Others.	Total.	Overseas.
1917,	20	58	78	8
1916,	7	29	36	1
1915,	4	16	20	4
1914,	6	18	24	2
1913,	8	11	19	3
1912,	11	7	18	1

There are twenty-five men in military service from the class of 1881 up through the class of 1911.

The total number of staff, students, alumni, and former students in military service at the present time is 355.

Scores of alumni in different parts of the country are rendering public service in connection with voluntary agencies or with agencies already established. Perhaps the two most notable examples of the public service which M. A. C. men are rendering in this connection are those of Mr. Daniel Willard, president of the Baltimore & Ohio Railroad, who is a member of the National Council of Defense, and that of Dr. Joel E. Goldthwaite, who headed a commission of medical experts to France to study problems of disease and physical incapacity.

The College Staff and Military Service.

Soon after the draft went into effect the question arose as to what the policy of the college should be concerning occupational exemption for members of the staff. It seemed unfair to the country to press for exemption of members of the staff as a class; it seemed unfair to the college to make no claims for exemption. Therefore in those cases where it was clear that the man's services were necessary in order to maintain college work the district board was asked to make exemption. But few of these cases arose. Therefore the college staff has been, of course, somewhat depleted, several of the younger men being drafted or volunteering for enlistment. Following is a list of those who have gone into military service: —

Windom A. Allen, Assistant Chemist, Experiment Station, in the draft camp at Ayer.

Wesley H. Bronson, Assistant Extension Professor of Farm Demonstration, United States Naval Reserves.

L. L. Derby, Assistant in Physical Education, Medical Corps.

Harold M. Gore, Assistant Professor of Physical Education, First Lieutenant, United States Reserves.

Burt A. Hazeltine, Instructor in Mathematics, teaching in radio school at Newport, R. I.

Roswell W. Henninger, Extension Instructor in Charge of Poultry Club Work, aviation school, San Antonio, Tex.

John B. Lentz, Assistant in Veterinary Science, Experiment Station, Captain, Medical Corps.

Bernard W. Shaper, Assistant to the Director of the Extension Service, Reserve Officers' Training Camp, Fort Leavenworth, Kans.

Robert S. Scull, Assistant Chemist, Experiment Station, chemical work, Washington, D. C.

F. A. Cushing Smith, Extension Assistant Professor of Landscape Gardening, aviation school, San Antonio, Tex.

John B. Smith, Assistant Chemist, Experiment Station, drafted, Camp Devens, Ayer, Mass.

Is Agriculture a War Service?

It has become almost a truism that agriculture should be regarded as a war service; but thus far it has not been possible to arrange for the definite assignment of men, either members of the staff or college students, to this form of war work. For example, the county agents indicated last summer that they would want at least forty students as agricultural supervisors the coming spring. It will be very difficult, indeed, to supply these men unless the new classification will simplify matters by listing men for specified war work other than strictly military service.

Helping Students to understand the War.

Ever since the severing of relations with Germany efforts have been made at chapel, through assembly speakers and in other ways, to present to the students the real meaning of the war. It has been necessary to handle this matter with considerable caution for fear of overstimulating the men in their attitude toward enlistment. One of the most interesting single aspects of the interest of the students was shown by the remarkable response to the appeal for funds, made here as in all the other colleges of the United States, to assist the Young Men's Christian Association in its war work in the military camps in this country and in Europe. We have no way of knowing what the normal allotment for this college would have been, but we suppose perhaps $1,500 to $2,000. The students themselves, through appropriate committees, decided to try to raise $5,000. As a matter of fact, the pledges amounted to over $6,000 from students and faculty, the students alone pledging nearly $4,500. Ninety per cent. of the students pledged something, and their average per capita was approximately $10. The response from members of the staff was exceedingly good.

A Shortened Year.

The faculty voted to shorten the collegiate year 1917–18 in order that students might remain in farm work as late as possible in the fall, and might be available for farm work early in the spring of 1918. Each of the three terms was shortened from twelve to nine weeks. Commencement will come April 27–29. Every effort is being made to keep up the grade of work.

Athletics.

Probably no department of the college has been obliged on account of the war to depart more widely from its customary program than has the department of physical education. Handicapped by reductions in the staff as well as by the lack of men and the shortened college year, a method was nevertheless devised for keeping up interest in athletic work which has met with a success extremely gratifying both to the department and to the students. Details of this plan will be found upon a succeeding page.

Late Opening.

In order to permit men in agricultural service to complete the season's work, the opening of college was postponed from the middle of September until October 10. Although students in order to receive credit for the full work of the previous semester were obliged to work only twelve weeks on farms, I think a large proportion of them continued work throughout the summer. Some even were not able to return October 10, because of the necessity of completing agricultural enterprises in which they were engaged.

Special Service of Individuals.

It is difficult to praise too highly the spirit of the staff in their relations to war work activities. I think it is fair to say that the entire institution has been almost completely mobilized for war service. In some cases, of course, the regular work constituted the service. For example, the members of the experiment station staff have kept at work on their regular projects, all of which have to do more or less directly with food production. The members of the extension staff threw themselves into the field work with increased vigor, if that were possible, sparing nothing of time and energy to meet the situation. So long as college classes were maintained, the majority of the teaching staff gave their time to their regular work, but as soon as the college closed in the spring, nearly every teacher took up some special form of war work to which he had been assigned. Quite accurate reports in detail are now available relative to the service thus rendered. It is not necessary to go into details in this report, but I may say that over 50 members of the teaching staff gave more or less time to this service, the amount of time ranging from a number of days to two or three, and in some cases four, months of solid time. The technical men, of course, as in agriculture and horticulture, worked in the line of their specialties, quite largely in the field. The science men either did work in connection with protection of crops and animals, the preservation of food, special investigations in connection with munitions, or occasionally in the work of surveys. The men in the Division of the Humanities engaged in a wide variety of work, some assisting in survey tabulation, others in supervision of garden work. I might specify some instances of types of service: assisting the field staff of the Hampshire County Farm Bureau; service in an information tent on Boston Common; helping in the developing of dairy records and in the poultry drive; community canning and preserving; garden supervision; emergency publicity and publications. A large number of the staff assisted in the surveys of farm labor, food production, consumption and distribution.

Professors Neal, Wheeler, Kilham and Hicks were practically "loaned" to the State Food Production Committee for the season. The last-named spent nearly four months organizing a very complete system of farm labor exchange in the State. His plan was so satisfactory that the United States Department of Agriculture practically took it as a model for their work in other parts of the country.

The emergency also increased very materially the correspondence in all departments of the institution; this was handled satisfactorily without addition to the clerical staff.

It helped, however, to make the year an unusually busy one. The war work, of course, has taken a good deal of the president's time since the 1st of March, as chairman of the State Committee on Food Production, and later as a member of the Massachusetts Board of Food Administration, as well as in various other capacities.

A number of our staff have been "loaned" for practically full time. The United States Department of Agriculture asked for Professor Hurd's services. About the 1st of August Professor Hurd went to Washington and has been there ever since, giving up his plans for his sabbatical year, occupying a very important position as assistant in the office of the Secretary of Agriculture. Professor Machmer has been released from his duties as assistant professor of mathematics in order to take an important position in field work in distribution in the western district of Massachusetts. Prof. W. D. Clark has been "loaned" to the Massachusetts Fuel Administration to assist in carrying on the campaign for the use of wood for fuel. Miss Sayles of the Extension Service has been released for the year for service with the home economics branch of the extension work of the United States Department of Agriculture.

Food Supply Studies.

The college, through its department of agricultural economics, and with the assistance of some eight or ten members of the general teaching staff of the institution, made elaborate surveys of food conditions in three or four counties.

A census of production in the five western counties, including nothing but *farm-grown* products, was conducted by the department of agricultural economics. The data collected covered acreages of farms, woodlots and improved land; number of live stock on hand in 1916 and 1917; acreage and quantity of various farm crops and vegetables produced in 1916 and proposed for 1917. A few facts stand out with special prominence, as revealed by the census, among which are the small number of farms and the small quantities grown on each farm. Although the census was taken in the four western counties before the crops of 1917 were sown, the reports indicate a probable increase in the acreage of several farm products.

The census in Worcester County was taken after the crops were planted, and it is significant that this county shows the greatest increase in acreages. The four western counties show an increase of 46 per cent. in acreage of corn for grain, 46.9 per cent. for potatoes, 150 per cent. for beans and 42.4 per cent. for green vegetables. Worcester County shows the greatest increases, — 110.5 per cent. in corn for grain, 46.5 per cent. for potatoes, 300.6 per cent. for beans and 84.4 per cent. for green vegetables.

A census of food consumption was also conducted by the department of agricultural economics. The territory covered included Hampshire County and a part of Hampden County. The data, secured from wholesale and retail dealers, transportation companies, storages and large consumers, such as hotels, restaurants and boarding houses, took account of certain staple foods, and the figures asked for showed quantities shipped in, reshipped, stored, sold and bought from local producers. The returns have been tabulated by towns, and reveal a notable lack of trade in home-grown products; but 22.4 per cent. of potatoes consumed are home grown, 7.8 per cent. of the beans, 33.2 per cent. of the eggs, 12.1 per cent. of the butter, 57.6 per cent. of the apples and 62.9 per cent. of the milk. Hampshire County produces 27.7 per cent. and Hampden County 18.8 per cent. of the grain needed by the live stock reported in these counties by the census of 1910. The three western counties, however, produce 6.4 per cent. more hay than necessary to feed the stock owned in the counties at that time.

In April, 1917, the milk situation in New England threatened to be very serious. Little usable information relative to cost of production was available. The committee on agriculture of the Boston Chamber of Commerce asked the agricultural colleges in the New England States to make surveys and report to them. Uniform blanks were used in order to make the returns comparable. The farm management demonstrator from M. A. C. supervised this work, not only in Massachusetts but in heading up the work of the other States. The blanks and all questions were passed on by our college dairy committee.

Two hundred and fifty farmers were selected by the farm management demonstrator in consultation with the county agents. Our college furnished seven men selected from the agronomy, animal husbandry, dairy and farm management departments. Their expenses were furnished by the Public Safety Committee. One man and his expenses were furnished by the Quaker Oats Company of Boston. These men visited the farmers and secured eighty-seven complete records.

The report of this New England work has been used not only in Boston but by milk committees in other cities. The information received in this survey was used and is being used, with changes in cost of variables, to determine the fair price of milk to the producer, thus avoiding a milk strike. Very favorable comments have been made on the results of the survey, both as to figures obtained and good accomplished by their use.

The poultry department co-operated with the county farm bureaus and the Public Safety Committee in a two weeks' "campaign" throughout the State of Massachusetts. The object of this work was, first, to collect accurate information about existing conditions among poultrymen; second, to attempt to check the injudicious sale of hens and pullets, but to encourage intelligent culling of the unprofitable birds; third, to commend the hatching of chicks through the month of June, where conditions warranted late hatching.

Nine men were employed to execute this work. In so far as possible, one man was located in each county, and he was given an outline of the uniform advice and data which had been adopted at a previous staff meeting. Public gatherings, farm visits and the press offered the best means of presenting the poultry doctrine, and these methods were adopted in each county. Accurate data from various sized flocks were used to show poultrymen what they could expect under existing conditions. The work, as a whole, was well received. While it has not been possible to measure results in a definite way, reports from different sections of the State indicate that the effort was worth while.

Vacations.

All the men on the staff, because of the tremendous pressure under which they were working during the spring, were advised to take the full month's vacation. Practically all of the teaching staff, some of whom are entitled to the longer vacation period, surrendered their privilege and gave their energy unreservedly to assistance in some form of agricultural mobilization work.

Publications.

The college agreed to issue, in co-operation with the Committee on Public Safety, special publications bearing on many of the particular problems that farmers would have to meet in speeding up production. A list of about 35 special bulletins was prepared during the year. Director Hurd devised a plan of post-card bulletins printed on both sides, which gave in compact form the best advice that the college could offer on these subjects.

Use of College Land for Food Production.

The trustees decided that all available areas of the college estate should be used in growing more crops. The following table shows what was done as war emergency production besides the regular crops usually grown.

Crop.	Acreage.
Beans,	13
Potatoes,	8
Corn,	7
Oats,	4
Squash,	3
Total emergency acreage,	35

The County Farm Bureaus.

The "projects" of the Committee on Food Production and of the Food Administrator have guided the major efforts upon which the farm bureaus have been spending their energy this year. In March all other plans were laid aside and the work for the season redrafted on the basis of the needs of the State during war times. The county food committees were, in nearly every case, comprised of men and women who were appointed by the advisory board of the farm bureau. The county agents acted as secretaries of these county committees on food production. When the organization of town food committees was suggested, the farm bureau used its organization to assist in securing the emergency committees in 244 towns. The work of the town committees was explained, and the local people were assisted in securing fertilizers, seed potatoes and land on which special work might be done.

In order to arouse the people of the State to a realization of the needs of this project, the farm bureaus assisted in over 400 meetings during the months of April and May. In one county alone the county agent addressed over 8,000 people in four weeks, urging increased production of food crops. The demand for the services of the county agents was so great that in four months the employees of the farm bureaus increased one-third, and the office force doubled. This was made possible by the appropriation which was made to the various counties by the Committee on Public Safety from its State appropriation, the conclusion being reached that the farm bureaus, having already been organized to direct and use efficiently trained workers, could secure results more rapidly than could be secured by the development of a new system. The farmers of the State, thoroughly aroused, increased their acreage of crops greatly, this increase being particularly noticeable in such crops as corn, beans and potatoes. The work with people other than farmers resulted in an extraordinary increase in home gardens.

The county farm bureaus more than justified themselves all over the country. Massachusetts was peculiarly fortunate in the fact that every agricultural county was fully or nearly organized for farm bureau work when war was declared. The food production and conservation campaign in the field was carried on through these county farm bureaus. On June 20 there were available for this work 20 men, 6 women and 10 clerks. On December 1 these employees numbered 30 men, 14 women and 20 clerks. Aside from these employees there were 14 men and 6 women who were employed for part time during the season.

Federal Aid.

In August Congress passed a law granting extra appropriations for food production and conservation work. Approximately $70,000 was assigned to Massachusetts, and was apportioned as follows, the work being administered in every case through the college: $54,500 was apportioned for food conservation from September 1 to June 30, and provided for a State leader for city work, 3 assistant county and city leaders, 9 county home demonstration agents, and also for assistant city organizers and supervisors in perhaps 30 cities, about 10 of these having now been provided. This is the regular educational work in home economics, food thrift, preserving and canning, etc., but carried out not only in all the counties of the State but also in the urban communities. Of course, in this field there are scores of agencies at work, and in all we are cooperating most fully with Mrs. Nathaniel Thayer, who is the official representative of the Federal Food Administration in Massachusetts, and with the State Executive Committee on Food Conservation.

Seven thousand dollars was set aside for junior extension club work for the same period, and permits the employment of an assistant State supervisor and ten county club leaders.

The sum of $8,000 was set apart for county agent work in marketing. This fund permitted the assignment of Mr. E. Farnham Damon as assistant county agent leader, with four district marketing specialists, in the Connecticut Valley, Worcester County, the area northeast of Boston and the area southeast of Boston. This work is educational in the subjects of marketing and distribution. Added to this sum was $36,000 granted to the county farm bureaus by the Public Safety Committee.

War Work Problems.

War Work Economies. — In common with other institutions and with individuals, it behooves the college to practice the most rigid economy during this period of stress. But what is economy and how can it be actually achieved? The drop in student attendance by no means indicates the practicability of an equivalent cut in expenditures. As a matter of fact, the so-called "overhead" expenses can be reduced very little unless whole courses or departments are abolished for the time being. For example, in the matter of the heating of buildings it is practically impossible to reduce coal consumption unless entire buildings are completely closed. What is true of maintenance is in large measure true of instruction costs. It is possible that some radical changes may be necessary for another college year. If we knew more accurately what our attendance would be, it would be much easier to make these adjustments. To what extent, it may be asked, are we justified in dismissing members of the teaching staff? We are holding positions open for those who have gone into military service. Is it not wise, on the whole, to maintain the teaching corps, and if their regular work be reduced because of decreased attendance, make it possible for them to render some form of special war service?

Research. — The staff of the experiment station feel that it would be exceedingly difficult and unwise to give up projects that are under way in research, for the reason that they are all connected more or less intimately with the soil or with animal or crop production, and consequently have an intimate bearing on the whole question of food supply. It is important, moreover, if we can possibly get the funds, to take up some special lines of research bearing upon the food emergency. This is notably true in connection with the canning and preserving of food. Very little scientific work has been done in this field. We are remarkably well equipped, both in material equipment and in men, for this work. Studies in the cost of production of milk have already been made, but more work needs to be done. Food surveys, both as to supply and demand, could be carried on to good advantage through our department of agricultural economics if the money were forthcoming.

Teaching. — We are putting forth every effort to maintain the standard of the institution and to keep intact the course of study. It is very difficult to do this, partly because so many of the students have gone, and because those who are left are more or less uneasy on account of the war situation. It is not an easy problem to keep up the standards, nor to decide what changes can be made in the number of the staff, salaries, courses of study, etc. We have no means of knowing how long the war will last. As soon as it is over we feel that the college must be prepared for a great influx of students. The interest in food production and supply will be greater than ever.

The Extension Service. — Of course, in one sense, the war service of the institution in the field has been entirely extension work. There has been an enormous increase in this work, and we could have used two or three times as many men as we have had at our disposal. In order to be of the largest service to the State we ought to have practically twice as many workers as we now have in the field.

The Staff. — The depletion in the staff raises an important problem, especially in connection with the younger men. It is almost impossible to get young men to take the places of those who have gone.

The Students. — It has already been indicated that the uncertainty of the situation makes it difficult not only to keep up the student body but to maintain the quality of work. The students, however, are very earnest and are doing their part as well as can be expected. The spirit of the student body is in every way magnificent. Fortunately, the reduction in the number of students does not deprive us of any large income, as it does in the privately supported colleges. On the other hand, it does not help us very much in reducing expenses, unless we deliberately cut out courses and departments; in other words, unless we fail to keep the institution "in trim" for the work it must do when the war is over.

The Food Supply and the College.

The war has not only accentuated the problem of food as a phase of war preparation and service, but it has also called attention to the fact that the question of food supply has a certain unity, and must be considered more fully as a single problem, not only for communities and for nations but for the world as a whole. The producers cannot be unmindful of their obligations to consumers, nor the consumers forgetful of the needs and rights of producers. The duty to save food everywhere, from the field to the table, has new meaning. The need of economies in production and distribution, as well as in use, are understood more clearly than ever before.

All this gives a new significance to the work of the agricultural colleges. It is rather strange, I think, that their function has been regarded as that of dealing only with the production of food and other things that can be grown from the soil. But it is becoming more clear now that they must deal with all the interests of those who till the soil. The work of the college must follow these interests as far as they may go, and it is apparent that they go a long way beyond the matter of production.

But I am wondering if we may not carry this matter even a step farther. Congress has placed in the hands of the Department of Agriculture — and, through this Department, in the hands of the various agricultural colleges — the task of teaching home economics to the people, not alone in the country but also in the city. Why should this not be a permanent function of the college? In this emergency the members of the staff of our college have been called upon to testify as expert witnesses concerning the costs of the production and distribution of milk, — a purely economic and business problem, not primarily a question of technical production. Why should our people be interested in the distribution of milk more than in the distribution of fruit or vegetables or hay? In other words, does not the very logic of events at least, if not a theory as to the work of the agricultural college, justify the statement that hereafter the college must concern itself with all the problems of food supply, and through its research, through field studies, and in its extension work, as well as in its courses of study, cover on the material side the entire problem of food supply? I should like to raise this question in a very definite way, because it has a most intimate bearing upon the work and activities of the institution, and in a State like Massachusetts, which is so thoroughly urban, a very important bearing upon the question of financial support. And this leads me to a few words concerning

Additional Funds for War Service.

I wish to urge the need of special funds for war service. This matter will come before you through the appropriate committees, but I think that we should have money from some source for special projects of an investigational character already referred to in this report, and that we should also take on, as soon as possible, a number of additional persons as members of the extension staff for service in the field. Now that attention to food has become recognized as a part of the war policy, is it not clear that the agricultural college, if it can serve the Commonwealth in times of peace, can serve her more greatly in this time of war? If agricultural education is worth anything, it is supremely worth while during the period of the war.

REVIEW OF THE YEAR.

Changes in Department Heads.

In March Arthur B. Beaumont came to the institution to assume the responsibility of head of the department of agronomy, with the rank of associate professor, filling the vacancy caused by the resignation in June, 1916, of Prof. Sidney B. Haskell. Professor Beaumont was born and reared in the south, graduating from the Kentucky State University in 1908; after five years of successful teaching in Oregon Mr. Beaumont returned to Cornell University for graduate study.

After three years of efficient service Associate Prof. Arno H. Nehrling, head of the department of floriculture, resigned in March, 1917, to enter private business in Indiana. Professor Nehrling was exceptionally well trained in floriculture, and continued here the development on a very high plane of the work inaugurated by his predecessor, Prof. Edward A. White. Professor Nehrling was a strong teacher, a good administrator, and enjoyed the complete confidence of the florists of the State. His resignation was a distinct misfortune to the institution. From March until the close of the college year the work of the department was carried on by Mr. Clark L. Thayer of Cornell University. Mr. August G. Hecht was selected for the position of head of the department, and assumed this responsibility in September. Mr. Hecht graduated from the University of Illinois in 1914, at which institution he has for three years been engaged as instructor, while at the same time pursuing graduate work. Professor Hecht is well trained both professionally and in the practical work of floriculture, and is proving to be an acceptable successor to Professor Nehrling.

When the first officers' training camp was opened at Plattsburg in May, 1917, Capt. Henry W. Fleet was ordered by the War Department to assume important responsibilities in connection with the training of officers at Plattsburg. Captain Fleet was in charge of our military work for a little over two years, and in that period won the complete respect and esteem of students and faculty; he elevated the work in military drill to a very high plane of efficiency, while at the same time correlating it with the other activities of the college in a most acceptable manner. Late in the summer the War Department detailed Col. Richard H. Wilson as commandant at this institution. Colonel Wilson is a graduate of West Point, and has had a very successful career as an army officer. The college is fortunate in having an officer of high rank assigned for the direction of its military work. (A complete list of changes in the various staffs appears as Tables I. to IV.)

Mr. Harmount's Death.

During the year death has claimed an active member of our teaching staff; Mr. William L. Harmount, after a serious illness of about four months, passed away at his home in Branford, Conn., July 20. Mr. Harmount came to the college in 1911 as instructor in French, and during the years of his service here gained the admiration of students and faculty alike. Although unassuming and retiring by nature, he won a warm place in the hearts of all his students because of his teaching ability, and because of his genuinely human interest in all who came in contact with him. Among his teaching associates he won high regard as a gentleman, as a teacher, and as a scholar of high intellectual ideals.

Attendance.

The total registration this autumn is 500 as compared with 680 a year ago, or approximately 75 per cent. of last year's attendance. Doubtless the falling off is due to the war. At least 100 men, who would otherwise have been here in the three upper classes this year, are in the army or with some other branch of the armed forces. The freshman class enrollment is 118 as compared with 170 of last year, and with 211 of two years ago. This decrease in the entering class is probably chargeable to a number of causes, such as the general unrest among young men, the consciousness of the possibility that they may not be able to complete their course before being drafted, and the unusually high wages which they can command in the various industries. (See Table VI. for analysis of enrollment.)

Unclassified Students.

In the spring of 1917 the faculty made more liberal provisions for the admission of so-called "unclassified" students; the new rule allows high school graduates to enter who are interested in the practical work of the college, but who feel that they cannot come for the four years' course. High school graduates of eighteen years of age, or older, will now be admitted without examination or the presentation of the usual certificate required for admission to the regular course. These students may remain in college for not more than two years, and are restricted in their work to the courses in technical agriculture and horticulture. That this ruling will meet a very definite need is evidenced by the fact that this autumn, in spite of war conditions, we have an enrollment of 50 unclassified students as compared with the enrollment of 29 of a year ago. This work is somewhat comparable with the special two years' courses offered at various other agricultural colleges.

Reserve Officers' Training Corps.

In harmony with a plan developed by the War Department for the training of reserve army officers, there was established at this institution during the winter of 1917 a branch of the Reserve Officers' Training Corps. Under the requirements of this system all students in the institution will drill and pursue studies in military science for two years; at the end of this time students who so choose may, if approved by the president of the college and the commandant, continue their military training on an intensified basis for the remainder of their college course. These students are required to attend military training camps in the summers, and upon graduation from the college may, provided they meet certain requirements, secure at the expense of the government such further training as will place them as commissioned officers upon a reserved list for a period of ten years. The government will in ordinary times furnish the uniforms for the lower classmen, and to those who are admitted for the advanced training the government will allow a cash payment for rations which will assist materially in meeting their college expenses.

COMMENCEMENT.

On account of the war, members of the senior class began to leave college in March, and all members of the class had by the latter part of May secured positions away from the college, either in military service or in some form of agricultural mobilization. Necessarily the usual plans for Commencement had to be entirely abandoned; it seemed desirable, however, to arrange for simple Commencement exercises, and to secure the attendance of as many as possible of those entitled to diplomas. Saturday evening, June 30, was therefore set aside for Commencement. The degree of bachelor of science was conferred upon 103 men and one woman. Of this number 65 returned to receive their diplomas in person. Nearly all of those who were unable to return were in military camps, although a few were engaged in important agricultural enterprises from which they could not be spared even for a day. To those who could not be present the diploma was mailed. On June 27 the degree of master of science was conferred upon eight members of the graduate school.

The Commencement program consisted of a dinner at Draper Hall, to which all seniors and members of the faculty were invited. The attendance was nearly 100. Following the supper were brief informal speeches by the president, the dean and representatives of the graduating class. At 8 o'clock the formal graduation exercises were held in the auditorium. The program consisted of music, a brief address by the president, and the awarding of the diplomas.

FIFTIETH ANNIVERSARY.

Soon after the outbreak of the war, in the spring, it was decided to postpone the plans for the celebration of the fiftieth anniversary which was to be held in October, 1917. The brief history of the college, on which Mr. L. B. Caswell of the class of 1871 had been working for some months, has recently been completed. Work on the college bibliography is also going forward. The pageant master, Mr. Langdon, was instructed to finish the writing of the pageant, and the pageant music was completed by Mr. Philip G. Clapp of Dartmouth College. The pageant and its music, therefore, are in such condition that their presentation can be arranged for at such future date as it may be considered expedient on which to have the postponed anniversary celebration.

Before leaving Amherst, Mr. Langdon read before our faculty, students and friends the principal parts of the pageant. Mr. Clapp was present, and gave a piano rendition of the prominent portions of the music. The opinion was unanimous that the pageant, if it could have been presented, would not only have been an attractive feature of the celebration, but would also have portrayed in a most impressive manner the development of New England agriculture, and the relation to it of the Massachusetts Agricultural College. We most earnestly hope that the pageant may be presented at some future date.

THE REUNION OF THE CLASS OF 1871.

October 2 marked the fiftieth anniversary of the coming on to the campus of the pioneer class of 1871. It seemed unwise to allow this anniversary to pass without some suitable recognition. Accordingly, arrangements were made with the class to hold a reunion here; the date selected, however, was October 12, in order that the class might be here after college should open. The following program was arranged and carried out: —

Thursday Evening, October 11.

Informal gathering at "The Davenport."

Friday, October 12.

8.30 A.M. Business meeting of the class at "The Davenport."
10.00 A.M. Class photograph at "The Davenport."
10.30 A.M. Auto tour of the college and environs in charge of campus committee on reception.
1.00 P.M. Dinner at Draper Hall; ladies invited; short addresses as follows: —
  Greetings on behalf of the faculty, President Butterfield.
  Greetings on behalf of the alumni, Dr. C. A. Peters, Secretary of the Associate Alumni.
  Greetings on behalf of the trustees, Charles A. Gleason, Vice-President.
  Response by Mr. William D. Russell, class of 1871.
  Brief statement concerning pageant, William C. Langdon, Pageant Master.
  Brief statement concerning history, Dr. Henry T. Fernald.
  Brief statement concerning bibliography, Mr. C. R. Green.

3.30 P.M. Public meeting in auditorium; address by Mr. William Wheeler, subject, "The Half Century Mile Post."

4.30 P.M. Informal reception in Room 114, Stockbridge Hall, to members of the class of 1871.

6.30 P.M. Class dinner at "The Davenport."

Fourteen of the 17 living members of the class were here; in addition, 3 members of the class who did not graduate joined with the others in their anniversary.

THE BOWKER AUDITORIUM.

I desire in this report to record formally the action of the trustees in giving to the auditorium in Stockbridge Hall the name of The Bowker Auditorium in recognition of the efficient and loyal service rendered the institution by William H. Bowker, a member of the class of 1871, and for over thirty years a trustee of the institution.

LEGISLATIVE APPROPRIATIONS.

The college asked the Legislature of 1917 for appropriations totaling $488,200 for buildings, equipment and improvements to the property. The college also asked for $35,000 for buildings, equipment and maintenance for the market-garden field station at Lexington. During the winter, as the price of coal and other supplies advanced, and as additional demands were made for an increase in the wages of laborers, it was deemed advisable to ask the Legislature for an emergency appropriation of $25,000 to help meet these unexpected financial obligations.

The Legislature finally agreed upon the following appropriations: $40,000 for improvements at the power plant, including a new chimney and an additional boiler; $33,500 for miscellaneous equipment and improvements; $10,000 for buildings, equipment and maintenance of the market-garden field station; and $17,500 to be added to the appropriation for current expenses.

ADDITIONS AND IMPROVEMENTS TO THE PLANT.

Contracts have been let for a new 450-horsepower boiler at the power plant, a new 150-foot radial brick chimney, and testing apparatus that will bring the plant to first-class condition. The roof on the power plant has also been raised. One of the most important improvement items was the rebuilding of the house at Mount Toby; this has been put in first-class condition, and is now occupied by a caretaker of the reservation. An additional glass laboratory for the department of botany has also been built. Numberless small changes have been made to keep the institution in first-class condition.

THE INVESTIGATING COMMISSION.

The investigating commission, appointed under legislative resolve by Governor McCall in the summer of 1916, was originally instructed to report to the Legislature in January, 1917. Finding that the time thus allotted was not adequate to make a thoroughgoing investigation of the work of the college, the commission received authority to postpone the completion of their report until January, 1918. The commission has continued its work during the year, and it is expected that the report will be made early in 1918.

THE WORK OF THE FIELD AGENT.

In July, 1916, a field agent was appointed. At that time there were no established lines of work for an appointee to this new office to take up. The important task of organizing adequate publicity is so new that I wish to quote somewhat from Mr. Gould's report.

> The problem in college publicity seems to concern itself with the systematizing, standardizing and centralizing of the publicity resources of the college. The primary function of the office was to collect and disseminate information concerning the Massachusetts Agricultural College. There was also turned over to this office the management of such institutions as high school day, alumni day and various conventions held on the campus.

The High School Project.

The purpose of this campaign was to acquaint Massachusetts high school men with the college. An appeal was made to the students in college to aid in this particular phase of publicity work in high schools. Their response was encouraging. Thirty-nine high schools were visited and 194 individual interviews with students were held. The individual consultations were held with those students who should have been or were seriously interested in M. A. C. Through this work it became evident that —

1. M. A. C. is little known and understood by a large number of high school men.
2. There are many men contemplating M. A. C. who are not really familiar with the work of the college.
3. There are not a few high school principals who are unfamiliar with the work of the institution.

The Project with the Granges.

Following the custom already in vogue, M. A. C. days with Pomona granges were arranged for with most of the Pomonas and a few locals. Illustrated lectures on the work of the college were given at 19 such meetings, reaching 1,505 people. The value of this program is doubtful.

The Excursion Project.

A project for community excursions to the college was prepared and presented to the county agents for their co-operation. No excursions of this special nature ever reached the campus, but 8 distinct organizations and several odd parties, totaling 1,162 persons, visited the college grounds between July 1 and Nov. 1, 1917.

Publications.

Publications issued from the office consisted of a Campus Guide, a booklet for high school men descriptive of the college, and a descriptive booklet for the department of landscape gardening.

THE THREE-TERM PLAN.

The academic year ending last summer was the first year in which the college has operated under the new three-term plan. It is still too early to judge the results. So far as first impressions may be a guide, it may be said that the plan has worked well. One feature of the scheme, which eventually may make it actually a four-term plan, was to have special courses during the summer. Several of these had been planned for this last summer, but had to be given up on account of the war emergency.

THE SMITH-HUGHES ACT.

During the year Congress passed a law known as the Smith-Hughes Act, appropriating Federal money for vocational education of secondary grade in the industries, agriculture and home economics. The law is administered in each State under a board of vocational education, which in the case of Massachusetts is the State Board of Education. The chief interest of the college in the operations of this act is twofold, — first, that we think it fair to assume that the Agricultural College will be the training school for teachers of agriculture under this act; and secondly, it gives a strong impetus to the development of secondary education in agriculture, already well started in Massachusetts under the State Board of Education, and gives added importance to the need of a co-operative plan with reference to the agricultural development of a State system of agricultural education. Your president is in consultation with the Commissioner of Education on all these subjects.

THE ANTI-AID AMENDMENT.

The college has always regarded itself as a public institution, and consequently has not supposed that it would be affected by the passage of the so-called anti-aid amendment to the State Constitution. It may be desirable, however, to have some legislation that will put on the statute books certain definitions of status that heretofore have given rise to some uncertainties in the State House.

It is understood that the method of electing members to the State Board of Agriculture will have to be changed. This is a matter that does not primarily concern the college, except as it bears upon the general question of the intimate relationship between educational and administrative work in such a field as agriculture. Furthermore, the fact that the secretary of the Board and the president of the college are, respectively, ex-officio members of the other Board brings up a detail.

The county farm bureaus, which have developed so rapidly in this State during the past few years, are considered by the United States Department of Agriculture, and by the college as well, as an organic part of the nation-wide system of agricultural extension service inaugurated by the congressional Smith-Lever Act. As a consequence, any legislation affecting these county farm bureaus is of concern to the college. The anti-aid amendment seems to make necessary the organization of these bureaus as public institutions rather than as corporations. We are co-operating, therefore, with the Federation of County Farm Bureaus in the endeavor to work out proposed legislation that will meet the requirements of the amendment, insure the effectiveness of the bureaus, and regard the interests of the college and the Department of Agriculture.

Co-operation with the Board of Agriculture.

During the early part of the year the State Board of Agriculture and the trustees of this college endorsed a statement of principles that should govern a division of labor between the two Boards and the institutions they represent. The statement is as follows: —

I. The State Board of Agriculture and the Massachusetts Agricultural College are, or should be, regarded as public agencies, to be supported by public funds and to be subject to appropriate State control.
II. The chief function of the State Board of Agriculture is administrative.
III. The chief function of the State Agricultural College is educational.
IV. There should be a standing joint committee on co-operation and adjustment, comprised of two or more members of the Board of Agriculture and a similar number from the Board of Trustees of the college, in addition to the secretary of the Board and the president of the college.
V. There should be distinct written agreements on the form and method of division of labor in all cases where there is, in the opinion of either institution, any overlapping or duplication of work.
VI. It is understood that in the matter of employment of members of the college staff as executive officers in the control or other work of the Board there will be definite agreements between the Board and the college.

The gist of this statement lies in the assignment of administrative work to the Board of Agriculture and of educational work to the college. The application of this principle will call for the consideration of some specific questions, such as the inspection of fertilizers and feedstuffs now administered under the direction of the Board of Trustees, and the Farmers' Institutes now carried on by the Board of Agriculture. Questions will also arise as to just what are administrative and educational activities. As a rule, these are clearly defined, but there will be instances where conference will be necessary to determine the correct assignment. I would recommend, therefore, that the trustees join with the Board of Agriculture in maintaining a joint committee of conference.

It is interesting to note that this autumn the Commissioners of Agriculture of the United States and the Association of American Agricultural Colleges and Experiment Stations joined in a somewhat similar statement of functions, in which this fundamental principle concerning administrative and educational work that we have already adopted in Massachusetts was the main feature.

The Year in the Departments of Undergraduate Instruction.

The dean reports that to the end of April the work of his office concerned itself with the usual routine of attendance, discipline and scholarship. At the beginning of the year the president appointed seven class advisers, three for the freshmen, two for the sophomores, and one each for the upper classes. The work of these advisers, especially the freshman advisers, was helpful to a good many students, not only in respect to scholarship, but in respect to personal problems and other matters. This larger supervision of the men justifies the continuance of the arrangement this year, and will justify the extension of it in the future. After the end of April, when the boys were allowed to go out on mobilization work, giving them credit for the term's work for doing twelve weeks of approved work, the task of following them up and keeping in touch with them devolved upon the dean's office. Inasmuch as there were reports to be received from the 500 odd students at the end of each month's work, and one each from employer and parent at the end of the three months' work, the dean's work was comparatively heavy. The correspondence was necessarily increased, inasmuch as many of the boys were constantly changing their positions and asking for information along numerous lines. The records were not complete, of course, until towards the end of the summer, so that the last year's work continued right up to the first days of the present school year. In the main, however, it was a pleasant task; the great majority of the boys were intensely earnest and deeply interested in their work. They made a fine record, — a record of which the college should always be proud.

Until the early spring the work of undergraduate teaching went on much as formerly. As a result of the war, however, a number of adjustments have been made. The work of practically all the departments has been modified to some degree better to meet the immediate demands of the hour. At the beginning of the present college year new courses were introduced for the purpose of more adequately preparing our students for supervisory positions another year. Additional work in conversational French has also been undertaken.

For the most part, the department heads have been retained, but a number of men in subordinate positions have left, some to enter the armed forces of the country, and some to take positions of larger responsibility elsewhere. A large number of teachers have been utilized during the spring and summer for special work in connection with the war service which the college has undertaken. One of the most urgent needs growing out of our war work is that of a department of horticultural manufactures. Professor Chenoweth has during the past months undertaken considerable work of this character in connection with his teaching in the department of pomology. For some years we have wished to develop work in this subject, and the emphasis now being placed upon the necessity of proper food conservation and preservation has driven home the importance of the immediate establishment of this department of horticultural manufactures.

The departments of poultry husbandry and agricultural economics in particular made use of the emergency in the spring to give their students field work in their respective subjects.

The department of agricultural education has made an analysis of the M. A. C. men who are engaged in educational work, and has also carried on correspondence with some 300 colleges with regard to secondary school agriculture as a subject for entrance credits for college. Correspondence has also been carried on with the principals of secondary schools in Massachusetts relative to the introduction of agriculture into the schools as a non-vocational subject.

There have come to practically all departments this year an unusual number of demands for trained men to accept attractive positions as teachers, farm managers and experts in other agricultural vocations. Only a relatively small percentage of these positions have we been able to fill.

Needs of various departments, which have heretofore been emphasized, have during the past year become even more pressing. In general, the teaching staff is adequate for the present demand. Several new buildings are, however, very badly needed. The more important of these are a new drill hall and armory, a library, a chemistry building and poultry houses.

After much study and conference there were developed during the past college year plans for work in technical agriculture and horticulture, designed to give every man entering the institution at the outset a general knowledge of the entire field of agriculture. This work was begun at the beginning of the present college year, and thus far it appears that the work has been conducted in an entirely satisfactory manner, and that it is meeting the hopes of its advocates. Owing to the resignation of Prof. John T. Wheeler, who has been the leader in developing this work, the plans for it are necessarily interfered with. We hope, however, that no serious interruption in the work will result.

In the department of physical education, owing to war conditions, a required course in field games has been introduced this October for freshmen and sophomores. This has been possible by the completion of the athletic field, which gives us ample room for handling large classes in outdoor games. During the winter months all juniors, sophomores and freshmen will be given two hours per week of special exercise prescribed by the War Department for students in colleges having a Reserve Officers' Training Corps. The shortening of the college year has made it necessary to abandon intercollegiate football and baseball. During the months of October and

November we have conducted a series of interclass football and track contests which have been very successful. About 125 different men participated in each Saturday program. The present development of general participation in games is due almost entirely to the completion of the athletic field. This development of outdoor work serves to emphasize more than ever the utterly inadequate indoor equipment. From December 1 to April 1 the drill hall floor is in almost constant use until 9 o'clock at night.

Under the provisions of General Orders No. 49, War Department, dated Sept. 20, 1916, an infantry unit of the Reserve Officers' Training Corps was established at this college on April 1, 1917, and since that date all instruction, both practical and theoretical, has followed strictly the curriculum prescribed in the orders named. The amount of time devoted to military work has generally been far beyond the requirements of the War Department. During the second and third terms last year special classes in junior and senior tactics of five hours per week were given. This training was in preparation for examination for admission to the Officers' Reserve Corps. During the third term seven hours per week were devoted to practical outdoor work, and the satisfactory progress attained was made the subject of favorable report by the officer making the annual inspection directed by the War Department. The military department of this college has co-operated with the Intercollegiate Intelligence Bureau of Washington, D. C., and has furnished to it a number of names of men fitted for special positions, such as agriculturists, chemists, editors, statisticians and draftsmen, etc.

During the year 3,162 volumes have been added to the library, making a total of 56,090. This number of accessions is smaller than for some years, and is largely accounted for by the entire absence of foreign books and periodicals. More work has been done by and for the faculty and others not connected with the institution. Requests by letter and otherwise for information concerning the purchase of books and periodicals, and the use of agricultural literature in general, have increased and become quite a factor in the work of the library. Records concerning the library extension work show an increase above all previous reports. In answer to requests from 56 libraries in the Commonwealth, 820 books and 170 bulletins were loaned from this department. Library leaflets listing books on better farming, dairying, home economics, farm machinery and vegetable gardening were published during the year. Up to this writing 28 leaflets in editions varying from 1,000 to 3,000 copies each, make a total printing of 36,000 copies. All of this work has been carried on with as much dispatch by the members of the library staff and others as the crowded quarters and disarranged equipment would permit.

Short Courses.

Owing to war conditions several additional short courses were developed. There were 110 pupils registered in the winter school of 1917, representing several States. The eighth farmers' week was held from March 26 to 30, with an attendance of 800. Polish farmers' day was held March 26, the attendance being 300.

In order to meet the demands of production, a series of two-day schools were held at the college during May. The registered attendance was not large, but some of the courses were well attended, and the work well worth while. One and two-day schools were held in 85 communities throughout the State from May 24 to August 22. The attendance was 10,213, with 12 instructors. The beekeeping school was held at Dalton with the usual success. The apple packing school was discontinued. A series of four-day schools for conservation work was held at the college during July. These schools were well attended and unusual enthusiasm was displayed.

A summer school of agriculture and country life was held as usual during July. The attendance of the school was somewhat affected by the pressure of the times. With the summer school was united a school for Y. W. C. A. workers, conducted under the auspices of the northeastern field committee of the National Young Women's Christian Association. This brought into the school several students from various States, who put much enthusiasm into our summer school. Some of the regular courses were discontinued in order to establish new courses along the line of conservation and production. The Poultry

Convention was held in July, and a good deal of enthusiasm was created. To the Ministers' Conference and Conference for Rural Organization were invited the leaders in the emergency war work, and the conference took on quite a successful appearance.

The supervisor of short courses calls attention to the fact that the short courses should have better financial support; the heads of departments are constantly calling for extra instructors and larger appropriations for laboratory supplies; also, one-year technical courses, such as poultry, animal husbandry and horticulture for students not of college grade; continuation courses of one year for graduates of agricultural high schools and departments of agriculture in high schools; a summer school of six or twelve weeks for pupils of college grade, with college credit, should be established.

It is the aim of the college to organize the short course work so that the citizens of the State may have a chance to come to the college for help and assistance, be it for a period of three days, three months or for a year. It is desirable that all the short courses be organized under the supervision of one man who should be given time to do this work.

The Year in the Graduate School.

During the year further progress has been made in the organization of the graduate school, and in the working out of a number of minor problems connected with the direction of this work. The more notable advances during the year are the formulation by the graduate staff of rules governing the theses presented for the graduate degree; a more definite basis has been established for the granting of credits for advanced degrees; the work required of graduate assistants has been standardized. Only half as many graduate students are registered this autumn as a year ago; this may be accounted for by the fact that the demand for trained men is this year almost unprecedented, and that there are most attractive opportunities for all such men who are not in military service.

The Year in the Experiment Station.

The station has been fortunate during the past year in retaining the services of the members of its staff in direct charge of important lines of investigation, with one exception. Dr. Van Suchtelen resigned to accept a position in his native country, Holland, and has been replaced in the department of microbiology by Dr. Itano. We have, however, lost a considerable number of assistants, chiefly through the operation of the selective draft. This in some cases has been followed by considerable interruption in lines of work in progress, as it is found difficult to replace the men thus lost with thoroughly qualified substitutes. Three important additions have been made to the station staff during the year — a field pathologist, an assistant in entomology and an assistant in the department of agricultural economics. The field pathologist has done a large amount of investigational work on the grounds of market gardeners, and experiments have been begun in the spraying of celery for blight and of beans for anthracnose. The new assistant in entomology, besides continuing the observations on the red spider, has undertaken the study of various insects doing serious injury in market gardens of the State, and an effort will be made, both on the pathological and entomological sides, to render the utmost possible assistance to the market-garden interests of the State, with a view to the prevention of injury to our more important food crops.

In the fifty-fourth annual report of the college will be found a somewhat full statement of the various lines of investigation in progress at the time of its preparation, and attention was called to the fact that in most of these continuance for a considerable number of years is essential. A restatement, therefore, of the ground just referred to appears to be unnecessary at this time.

The serious situation as affecting food supply due to the European war suggested the desirability of a careful consideration of the question as to whether lines of investigation in progress should not be modified and new ones undertaken. With a view to getting suggestions from individuals who it was believed are as well qualified to make such suggestions as any in the State, a meeting of the advisory council was called in June. The investigations in progress were quite comprehensively, though of necessity briefly, described, after which opportunity was given for discussion and suggestions. If we may judge by the fact that no important new investigations were suggested, it would appear that the scope of our work as affecting food production and distribution was regarded by the members of the council present as at least fairly satisfactorily covering the ground.

During the past year, however, we have undertaken a few new lines of investigation. In connection with the cranberry substation in Wareham we have established in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture a plantation of swamp blueberries, with a view to investigating the possibilities of blueberry culture. The very high price of the cereal grains has indicated the probability that under existing conditions Massachusetts may profitably engage in the production of these grains on a much more extensive scale than in recent years. A considerable area on the Tillson farm and a smaller area on the home grounds of the station, therefore, are being used for the trial of nine different varieties of winter wheat and of new varieties of winter rye and winter barley. The chemical department, in co-operation with several other experiment stations, under the general suggestive leadership of Dr. H. P. Armsby, is beginning a series of experiments to determine the minimum protein requirements of growing animals. The solution of this problem should have an important bearing upon the economy of meat production. A number of forage crops new in the agriculture of the State and a considerable number of feeds also relatively unknown, have been under investigation as regards their value and adaptability to local conditions.

Important investigations which should throw light upon the most satisfactory methods of feeding horses have been begun during the year. In these investigations the digestibility by horses of the important foodstuffs and their available energy in the animal economy will be determined.

Experiments having indicated the superior value of the types of rust-resistant asparagus produced in the breeding work in

Concord, a considerable area has been set with plants of the best variety for the purpose of producing seed in such quantities that the demand of growers of the crop for the new varieties may be met.

As the probable value of soy beans in the existing and prospective food emergency has been quite generally recognized, it was felt that there would be a large demand for seed, and a considerable area on the Tillson farm, as well as smaller areas on such of the station plots as could be used for the purpose, have been planted to one of the best varieties.

Fairly satisfactory progress has been made in the investigation into the causes of tobacco sickness, although a hail storm of exceptional severity did much damage to a portion of the plots.

The station has been exceptionally active in publication during the past year. Five important bulletins have been published and distributed, and no less than six others are either in the printer's hands or now ready to go forward.

Several of these are of permanent scientific value, and must ultimately prove useful through pointing the way to a more successful production of some of our important agricultural specialties or to a reduction in the cost of production, while others are of direct practical importance in the existing food emergency. In addition, several of the station workers have prepared for publication in scientific journals important papers dealing with results obtained in station investigations.

The control work of the station has received the usual careful attention. Bulletins reporting the results of the inspection of fertilizers and feeds have been prepared. The high price and scarcity of fertilizers seems to have suggested unusual activity on the part of those engaged in the production and sale of relatively worthless articles. An energetic campaign believed to have been quite successful was carried on with a view to preventing or limiting the amount of such sales.

The blood tests for bacillary white diarrhea, with a view to the elimination of this disease from the State, has been energetically prosecuted, and this is highly appreciated by our poultrymen.

NEEDS OF THE STATION.

Land and Buildings. — The needs of the station were stated with some fullness in the report for last year, and it seems unnecessary to repeat the statement in full at this time. The needs particularly emphasized were the purchase of the Tillson farm and the erection thereon of a barn and dwelling house; the acquisition of land for a poultry farm; the purchase of the land leased for the stock and scion and other orchard experiments; the provision of a small orchard for the special use of the entomological department in connection with its study of spraying problems; the provision of buildings for experimental purposes at the market-garden field station. The purchase of the Tillson farm is the only one of these needs which has been met. For the other purposes indicated it is estimated that the following sums of money will be required: —

Buildings on the Tillson farm, ...	$10,000
Land for the poultry farm, ...	8,000
The purchase of the Tuxbury land, used for the orchard experiments, ...	12,000

It is believed that the small orchard needed for the work of the entomological department should be located upon land now the property of the institution and near the headquarters of the department.

Increases in the Staff. — Attention was called in the last annual report of the station to the fact that there is decided need for experimental work in rural engineering, in floriculture and in forestry. Provision for this work should be made at as early a date as possible. Particularly urgent are investigations in rural engineering and in forestry. Owing to the unusual conditions affecting the finances of the State, provision for these investigations may of necessity be somewhat deferred, but it is hoped that it may be possible to provide for increased work along lines of investigations particularly important in the present emergency within the limits of our present appropriations. The plan which seems to promise most important results of immediate and practical value is the employment of graduate assistants who will study, under heads of existing departments, some of the problems most urgently demanding prompt solution. Food conservation and canning are among the more important of the subjects which should be thus provided for.

The experiment station is carefully inspected every year by a member of the staff of the office of experiment stations. The inspection this year was carried out by Dr. E. W. Allen, chief of the office, and it may not be out of place to call attention to the fact that after finishing his inspection, and just before leaving, Dr. Allen expressed his hearty satisfaction with the conditions he found. He stated that he felt that the administration was carefully looked after, and that we were accomplishing a very large amount of highly valuable investigational work. He added that it seemed to him that the scope and amount of work must be regarded as extremely satisfactory.

Market-garden Field Station.

In 1916 Mr. H. F. Arnold, then president of the Boston Market Gardeners' Association, introduced into the Legislature a bill requesting $20,000 for land and buildings and $10,000 for equipment and maintenance for a market-garden field station, which would be under the general direction of the Massachusetts Agricultural College. The Legislature of 1916 appropriated $8,000 to cover all purposes above mentioned. The final location of the property was decided by the trustees Nov. 9, 1916, and the following month the purchase was consummated. The parcel of land selected is located in East Lexington, and comprises 12 acres. The purchase price was $400 per acre. As weather permitted during the winter of 1916 and during the spring of 1917, the land selected was improved by the construction of roads, drainage, the removal of rocks, etc. The cost per acre for these improvements was $167.48, making the final cost per acre $567.48. In 1917 the trustees of the college requested $25,000 for buildings and equipment and $10,000 for maintenance to Dec. 1, 1918. The Legislature appropriated $10,000, to be expended as follows: $3,500 for a service building, $1 500 for equipment, and $5,000 for maintenance to July 1, 1918. Work on the service building was begun Aug. 7, 1917, and is now practically completed.

The appropriation for equipment and for maintenance is being spent as planned.

The farm operations of 1917 were confined to the growing of cabbages. Ten acres were set to this crop. The yield was fair, and the sales up to December 1 approximated $1,500.

As yet the field station is not adequately equipped to meet the expectations of those most interested in it, and accordingly the direct beneficial results are not greatly in evidence. The market gardeners, however, are interested in this project, and it is expected that, with their co-operation, the work may speedily become organized on an entirely satisfactory basis.

The results of the farming operations in 1917 have put the soil in good condition and resulted in the practical extermination of witch grass. While the land will not be in ideal condition for all garden crops in 1918, much more can be done with it than during the past season. Plans are under way to carry on several demonstrations, which should be of immediate value to vegetable growers in Massachusetts, and to start several experiments of fundamental importance to this type of Massachusetts agriculture.

The Extension Service.

The war has brought many changes in the personnel and the work of the extension service, and these began long before war was declared. Every effort has been made to meet the ever-changing conditions that have confronted us. The work developed so rapidly and the changes came so fast that it was very hard to do things in as substantial a way as might have been desired. In reviewing the year's work, however, we feel that in the main the work was well done, and that every worker did as well as possible under the conditions.

Changes in Staff. — Both permanent and temporary changes have been made in our staff in the past year. Director Hurd, who is on leave of absence until next July, is serving in Washington as special assistant in the office of the Secretary of Agriculture. Prof. Austin D. Kilham is serving very acceptably as acting director. The assistant director resigned early in the year and his place was taken by an assistant to the director. Four members of our staff have been granted leave of absence to enable them to do war work. Capable extension workers are becoming very scarce, and it is becoming more and more difficult to fill either temporary or permanent positions.

Co-operation with Other Agencies. — During the past year very pleasing co-operative relationships have been maintained with all of the organizations mentioned in the annual report of last year. The most noteworthy additions to this list are the Massachusetts Committee on Public Safety and the State Food Administration with their subordinate committees. Immediately upon the formation of the committee on food production and conservation of the Massachusetts Committee on Public Safety, the extension service as a part of the college was placed at the disposal of the committee. Every member of the extension service helped the work of the committee in some way. A few members of the extension service devoted several months of their time entirely to the work with the Committee on Public Safety. The relationships have been most pleasing and gratifying.

There is now time to work out the relationships and methods of work for 1918 more carefully than was possible last year.

Co-operative Work with the United States Department of Agriculture. — Relationships with the United States Department of Agriculture have been strengthened. Several new co-operative projects have been undertaken with the Department. Many of these projects are temporary in character because they are maintained on emergency funds which may not be available after June 30, 1918. New projects are: (1) urban emergency home demonstration work; (2) rural emergency home demonstration work; (3) emergency county agricultural agent work; (4) emergency junior extension work; (5) truck crops disease work; (6) soft cheese demonstration work; (7) sheep production.

County Agent Work. — There is now completed the skeleton organization of the farm bureau work, as every agricultural county of the State now has its farm bureau organization. The farm bureaus in Middlesex, Dukes and Nantucket counties have been organized in the past year. The Middlesex County farm bureau has a staff consisting of a secretary, a county agricultural agent, a home demonstration agent and a boys' and girls' club worker. The Dukes and Nantucket farm bureaus have joined to employ two workers, — a county agricultural agent and a home demonstration agent. The organizations and the preliminary work of the farm bureaus in Dukes and Nantucket were materially aided by the Massachusetts Committee on Public Safety.

Practically all of the farm bureaus have been strengthened by the additions of permanent or emergency workers. The Massachusetts Committee on Public Safety helped at a time during the summer when pressure was urgent and when funds could not be obtained elsewhere, by furnishing funds to carry on temporary work. Soon after the emergency funds of the United States Department of Agriculture became available, in August, some of this support was dropped. A very important portion of the county agent work is still supported by the Massachusetts Committee on Public Safety.

The development of local leadership, both for adult and junior extension work, was a very important part of the year's work in most counties.

The regular projects were followed during the early part of the year. Emphasis was placed on the organization of the dairy industry until that situation was relieved by the organization of the New England Milk Producers' Association. Later, the county agents assisted with the special survey on the cost of milk production.

Early in March came the call for assistance in a nation-wide campaign for increased food production. The regular projects of the farm bureaus were suspended and a large part of the time of our county workers was devoted to special work. The organization of the town committees on public safety and food production necessitated some quick and exacting work on the part of the county agents and others to arrange matters satisfactorily and without friction.

Four emergency agricultural agents at large have been employed under a co-operative agreement with the United States Department of Agriculture and the State Food Administration. These special agents work in close co-operation with the regular county agents on marketing problems. They have been placed in the following districts: —

District 1, Essex and Middlesex counties.
District 2, Barnstable, Plymouth, Bristol and Norfolk counties.
District 3, Worcester County.
District 4, Berkshire, Franklin, Hampden and Hampshire counties.

Agents are now at work in all districts except District 2.

Rural Home Economics. — The regular rural home economics work has been speeded up in an endeavor to meet the present emergency. Early in the year three emergency workers were employed throughout the State. The work was somewhat disorganized by the absence of Miss Comstock during the summer, and the loss of Miss Sayles after the 1st of October.

Upon the passage of the emergency food bill the three temporary workers were placed on United States Department of Agriculture funds, and were made assistants to Miss Comstock as State leader of rural home demonstration work.

The organization of the county home demonstration work now takes the greater part of the State leader's time. With the emergency work that is now on, it is not possible for all of the organization work to be done. It is highly important, with the development of home demonstration work in the farm bureaus, that we obtain high-class specialists to work in various lines. A specialist is needed in sewing and one in household management.

Urban Home Demonstration Work. — Immediately upon the passage of this bill Miss Antoinette Roof was appointed State leader of home demonstration agents urban. Three assistants were also appointed. Two difficulties at once presented themselves — first, to find properly qualified city leaders; second, to secure co-operation and financial support in the various cities. More than 50 candidates were interviewed to secure the present force of 17 workers. Of this number, 2 are assistants to the State leader, 11 are city leaders, and 3 are assistant city leaders. The fact that 11 cities have been found in so short a time that are willing to give financial aid to this work indicates that there is a real demand for it. Special attention has been given to the organization of the work in each city. In most cases an executive committee has been appointed for each city, with local committees in each district. The city leader finds many organizations with which to co-operate, and in most cases finds many volunteer leaders who have had training in home economics or who have special qualifications because of their nationality.

The organization of the work in the cities should be strengthened and better co-operation secured with all existing agencies. Better financial arrangements will have to be made if the work is to be permanent. Extension schools should be held to train local leaders.

Junior Extension Work. — After the appointment of the Public Safety Committee in the early spring, work was begun to interest the young people in food production and conservation through the agency of public meetings, lectures at schools and school organizations. Four workers were employed permanently, and at certain times, when increased pressure demanded a greater force, the number was increased to eight. The Massachusetts Public Safety Committee financed a large part of the additional work. After the passage of the emergency agricultural bill an assistant State leader was appointed. This made a permanent staff at the college of five members, consisting of a State leader, an assistant State leader, a pig club agent, a poultry club agent and a home economics and canning agent. Since Dec. 1, 1916, approximately 58,664 people have attended demonstrations and meetings held in connection with their work. During the past year emphasis has been especially placed upon organization. Effort has been made to work through the county farm bureaus as far as possible. In a majority of the counties club workers were employed for the first time. These county workers endeavored to find local leaders in the various communities who would take charge of the work in smaller groups. In Hampden County 18 of the 20 towns appropriated money for local leadership as a result of the effort of the county club leader. In Franklin and Hampshire counties several towns at their annual meeting appropriated money for this work. In many cities the school departments appropriated money for club work. In most cases this money was used to pay the salary of a supervisor or a supervisor and assistants. Our records show that there have been at least 230 paid local leaders and 240 volunteer local leaders who have conducted work during the past year.

At the suggestion of the Norfolk County agricultural agent a new form of work is being tried out under the direction of the assistant State leader. Junior extension schools are being developed in which it is hoped that a larger amount of thorough instruction will be given than has been possible in the past.

Boys and girls in many instances did canning work in units. As many as 3,500 jars were canned by some of these groups, and several records were made by individual boys and girls who canned from 500 to 800 jars of fruits, vegetables and greens. The figures at hand show great increase in interest, not only on the part of the children but also adults.

Special Extension Schools. — As a part of the emergency work three four-day training schools for leaders were held at the college July 10 to 13, 17 to 20, 24 to 27, to which 83 persons came, representing 45 towns in the State. Five instructors conducted these meetings. Food conservation schools of one and two days' length were held May 24 to August 22 in 85 communities throughout the State. Five of these covered a period of two days, while the remainder were one-day sessions.

Aside from these well-recognized projects, 49 members of the college staff, experiment station and extension service delivered 897 lectures before various organizations and communities at which there was an estimated attendance of 58,305.

Horticultural Manufactures. — Previous to 1917 this very important line of work was carried on in a very meager way under the pomology extension project. Early in the present year Professor Chenoweth developed this as part of the campus mobilization work. Material aid was given to community canning and evaporating centers. Schools were held for leaders at the college, and schools and lectures were given throughout the State. Plans are under way to carry this work on in a very practical way during the next year.

Special Campaigns. — In order to meet the unusual situations the past year several special campaigns were carried on. Among the most successful was the poultry campaign which was developed by our poultry department in co-operation with the Massachusetts Committee on Public Safety and several other organizations. Reports indicate that these campaigns have been very successful.

Summary of Recommendations. — The results of the extension work showed very clearly during the past year that the extension staff, including the county agricultural agents, has been ready to meet emergencies. It has also been shown that it is very inadvisable to take the men off their regular lines of work to do a large amount of special work, even in so great an emergency as last year. Each of our workers is developing a special project which is just as important in time of war as in time of peace. Material harm was done to some of our permanent projects by the emergency work last year. It would seem advisable, therefore, to increase the staff, so far as possible, to meet the emergency rather than to take our specialists away from their regular and important work.

Budgets which will soon be presented will indicate the needs for the coming year in regular work and for emergency work. Special mention is made by the acting director of the following: —

1. More help should be obtained from the United States Department of Agriculture in correlation of our work both with the Department and with the farm bureaus.

2. More money should be obtained from the State treasury to be used through us by the county farm bureaus.

3. The rural home economics work should be better developed, to include, in addition to the State leader, highly trained specialists in food, clothing and household management.

4. Appropriation should be made for the maintenance of the urban home economics work.

5. Well-trained men should be secured to work out better methods for our itinerant instruction. This should be done whether the man is called assistant director or a specialist in this work. It may be advisable to reorganize our present scheme and place the administrative work along these lines in the hands of one of our present force, but it is very necessary that we have a man who is really a specialist on itinerant instruction. This is very important.

6. More money should be given us for printing and publicity. A great deal more could be done in this line.

7. Correspondence course work should be further developed. This cannot be done until further funds are secured.

8. Library extension work should be developed. This will require a part-time worker.

9. This seems to be the time to do some rapid work in community and county organization.

10. Plans should be made to carry on the present co-operative organization and marketing work in case the United States Department of Agriculture funds are not available after June 30.

11. The specialist in pomology should devote practically all his time to the demonstration orchards. Other work should only be done when it is possible to secure another worker.

12. There should be a full-time worker in dairying.

13. Civic improvement work should be dropped until the end of the war.

Most of the college teachers have responded to the call and given a great deal of their time and attention to the work off the college grounds as well as to special work on the campus. We expect a similar response another year. The extension staff, including the clerical force, has met the many unusual situations of the past year in a fine spirit of service.

THE IMMEDIATE NEEDS OF THE COLLEGE.

Legislative Budget, 1918.

Because of the abnormally high cost of building materials and of labor, and also because both of these are in such demand for the more adequate prosecution of the war, the trustees at their October meeting decided not to ask the forthcoming Legislature for appropriations for any new buildings, although the need for the library, armory, chemistry laboratory and the dormitory is as urgent as ever. There are, however, several miscellaneous projects for improvements and equipment which have been pressing for some years, many of which are absolutely essential for the most efficient conduct of our work at this time. After careful consideration of these projects the trustees have prepared a budget which includes the following items: —

Improvements at the power plant, including coal-handling apparatus, turbine house and equipment, and residence for engineer,	$59,700
Improvements at dining hall,	12,000
Poultry buildings,	7,500
Potting shed and bulb cellar at greenhouses,	6,659
Miscellaneous improvements in buildings and grounds,	30,306
Miscellaneous teaching, operating and office equipment,	20,680
	$136,845

Buildings, equipment and maintenance of market-garden field station at Lexington: —

Greenhouses and heating plant,	$13,500
Foreman's cottage,	4,500
Administration building,	7,500
Maintenance,	3,000
	$28,500

Following is a brief explanation of the need for the appropriation requested: —

Improvements at the Power Plant, $59,700.

The equipment for furnishing electricity for the institution is inadequate for the present demand. There is now in use one 100-kilowatt Curtis General Electric turbine, and one

50-kilowatt Terry generator. The institution is now using in excess of 400 kilowatts. We are asking, therefore, for an additional 300-kilowatt Curtis turbine and exciter, to cost $9,000. The following equipment will be necessary for this turbine: switchboard, $3,200; piping, valves, fittings and labor to connect turbine house machines with the boiler house, $5,000; a 5-ton crane for turbine house, $1,000; moving old machines to the turbine house, and connecting switchboard with old electrical lines, $1,000; the cost of the new turbine house to care for this equipment is estimated at $14,000.

For economy in operation we desire to install additional coal-handling apparatus to cost $22,000; this equipment will make possible a saving of 75 per cent. of the cost of labor of handling coal.

At the present time the chief engineer lives over a half a mile away from the power plant. Without question it is desirable, if not imperative, that the engineer should live near the plant. We are, accordingly, requesting an appropriation of $4,500 to provide a suitable house for the engineer, to be located close to the power plant.

Improvements at the Dining Hall, $12,000.

This appropriation has been asked for in previous years, and the need is now even greater than formerly. The amount specified would be used for installing suitable toilet facilities in the basement; for constructing a cold-storage plant for potatoes and other vegetables; and also to provide adequate storage for the coal used for cooking purposes. In addition to the cold-storage plant for vegetables a complete refrigeration plant is required, furnishing separate compartments for meat, milk, butter, fruit, eggs and miscellaneous left-over foods.

Poultry Building, $7,500.

The poultry department is inadequately equipped with buildings necessary for the proper conduct of its teaching and investigational work. This is due in part to the fact that the department has been established only a comparatively short time, and the equipment has been added gradually. The present request is for funds to provide a poultry house for stock and for use as a laboratory. The building proposed will contain twenty-four pens, a laboratory for general demonstrations, and a large room on the second floor to accommodate 25 to 50 students.

Potting Shed and Bulb Cellar at the Greenhouses, $6,659.

In order to facilitate the work of the department of floriculture we propose to build a potting shed and manure tanks. The potting shed will have a basement for bulb storage.

Miscellaneous Improvements and Equipment, $50,986.

Each year we are obliged to seek an appropriation for miscellaneous improvements in buildings and grounds, and for miscellaneous teaching, operating and office equipment. Inasmuch as our requirements are never met by the Legislature, the list of improvements and equipment presented this year is, therefore, somewhat of an accumulation of needs of long standing. The total of projects approved by the trustees is indicated by the above figures, divided as follows: improvements, $30,306; equipment, $20,680.

Equipment, Improvements and Maintenance at the Market-garden Field Station, $28,500.

In order properly to develop the work of the market-garden field station at Lexington additional buildings and equipment are necessary, and the appropriation for maintenance must be renewed. The estimated gross expense for maintenance is $3,000 to Dec. 1, 1918. An appropriation of $7,500 is asked for an administration building to provide offices, storage for records, a small laboratory to take care of the work which must be done immediately on the grounds, a committee room, a dark room for photographic work, accommodations for the heating plant for the administration and service buildings and the foreman's cottage. The sum of $4,500 is requested for the construction of a cottage for the resident foreman. An appropriation for greenhouses and heating plant was asked for last year, but not granted. This request is renewed at $13,500; this will provide four greenhouses, each 40 by 75 feet, and a heating plant to care for the same.

General Financial Needs.

The five years' appropriation for maintenance of the college granted in 1913 expires Nov. 30, 1918, unless renewed. The commission to investigate the college will soon make its report, and our action as a Board will have to be governed to a large extent by the character of the recommendations of this commission relative to financial support of the institution. At this time, therefore, I cannot make specific suggestions, and can only reiterate the statements and arguments attempted in my report of one year ago, relative to the general question of method of supporting the institution.

Your Board of Trustees have agreed that it was unwise to ask for large buildings at this time, partly because the resources of the State are taxed to an unusual degree on account of the war, and partly because the excessive cost of building materials seems to make the erection of expensive buildings at this time rather unwise.

The question of financial support for the coming year is, however, somewhat acute. In spite of the reduced attendance of students, the cost of maintenance of the institution is not greatly reduced. Wherever it has been possible to carry on the work persons have not been appointed to vacancies made by resignations due to war work or other causes. This policy will to some degree reduce the salary pay roll. On the other hand, the very rapid increase in the cost of living during the past two years raises an exceedingly important question relative to the salaries of members of the staff. This question is peculiarly important in the cases of those members of the staff who are receiving moderate incomes, both in teaching and in experimental work, and perhaps presses, if possible, with even greater force upon the clerical staff, who, in my judgment, are not sufficiently paid anyway. I am inclined to think that it would be wise, as it certainly would be only fair, to grant a bonus or temporary increase of salary to certain members of the staff for the coming fiscal year.

The treasurer thinks that coal will be higher rather than lower. We are doing all in our power to reduce the consumption of coal, but the gain here is more than offset by the extra cost of coal. Labor, of course, is high, as well as supplies, so that the maintenance cost of the institution, even under reduced sail, is not materially lessened.

Moreover, there are good reasons why certain emergency enterprises should be undertaken. During the past year the college spent at least $8,000 — entirely apart from any question of salaries or services of men — in travel, correspondence, publications and clerical help — work that was entirely abnormal and wholly war emergency service. This type of expense is bound to continue so long as the war lasts.

Furthermore, I believe it to be the duty of the institution to do everything in its power to contribute to the problem of food supply. There are certain investigations that ought to be made. There are certain phases of expert service that we cannot render because we have no men on the staff to do the work, so that we could spend considerably more money in our extension service while the war is on. One of the most important aspects of war service that could be rendered would be to establish on a sound foundation our new department of horticultural manufactures. This has such an intimate relation to the saving of wastes, the canning, drying and preserving of foods, the rendering of unsalable but clean product into a multiform variety of juices, jellies, etc., that it could make a contribution of utmost consequence at this time.

Women at the Massachusetts Agricultural College.

Women were first admitted to the Agricultural College for college grade work in 1899. Since that date there have always been a few in attendance for degree courses, and, including the class of 1917, 10 women have received the diploma of the institution. Of course, during all these years many women have attended the winter short course, and the summer school attendance has been composed largely of women. There was never any prohibition of women attending the college, and so far as I can discover there has been no real prejudice against it, at least in recent years. Neither from students nor from faculty have I heard of serious objection to the attendance of women. On the other hand, no encouragement has been given women to attend. There has been no special provision for their housing nor for their college life and activities. There are several reasons why it seems necessary at this time to give special attention to this phase of our work.

1. There has been a notable recent increase in the enrollment of women. During the collegiate year 1912–13 there were 5 women here; last year there were 25; this year there are 30 women, 6 of these being freshmen.

2. The Massachusetts Agricultural College is the only land-grant college in New England, and I think I am correct in saying the only one in the north, that does not have special courses and provision for women. This fact is not necessarily conclusive as to our own policy; it does, however, indicate that we stand alone in the policy, and consequently must justify it if it is to be maintained.

3. The development of woman's interest in agriculture is rather notable. The number of women farmers in the east seems to be increasing. The organization of women interested in agriculture, started some years ago, has been fostered by the war and has become a strong movement. The mere fact that girls are taking courses in agriculture, short and long, in rapidly increasing numbers, is of utmost significance. It is worth noting that before the war European as well as British agricultural educational systems were providing increasingly for women.

4. The emphasis upon the importance of food thrift in this war has increased immeasurably the need of providing for the education of women in certain lines of endeavor for which there is now wholly inadequate preparation. Questions as to the use of food, the saving of food, the preserving of food — to a large extent matters in charge of women — raise nothing less than an issue.

5. There is a fundamental reason why an agricultural college should provide courses for women. For fifty years we have been endeavoring, through research and teaching and extension service, to enable the farmer to make more money from his farm. As already noted, many of the land-grant colleges have courses in home economics. It is doubtful, however, if any college has yet adequately provided for the training of women for rural home making in the same sense that they have

attempted to train the men for farm making. But however that may be, and whatever may be the difficulties in the way of carrying out such an ideal, the fact remains that the whole field of rural home making needs to be developed, and can be developed adequately only in the atmosphere of an agricultural college.

6. There is a growing demand for the training of women for positions in social service in connection with country life. While the normal schools are training teachers for the rural towns, still some aspects of this training can better be carried on at an agricultural college than anywhere else. We already have calls for community nurses, for directors of recreation and for Y. W. C. A. secretaries in the country. These calls are likely to increase, and they need trained women.

Some Considerations.

1. This plea for the recognition of women raises at once the question as to whether the college should enter upon a scheme of coeducation. Personally, I am convinced that this question is largely one of habit. The men's colleges of the east and south are very loath to change their policy and admit women, and I think the women's colleges of the east rather pride themselves in their plan of segregating women. On the other hand, the State colleges and universities of the north have practically always been coeducational. So far as I can discover there is no tendency to change their policy. I have come to feel that the best plan for a college situated as we are, and with its history and practice, would be to develop work for women in a way that would combine in a measure the advantages of both plans. I think, in other words, we should have on the campus what would virtually be an affiliated institution where the women would be considerably segregated, and would in large measure have their own teachers, their own buildings and their own social life. At the same time, there would be no artificial barriers of isolation. Mixed classes would prevail wherever they were economical, separate classes wherever the numbers warranted. So far as practicable, all the resources of classroom, laboratory equipment and teaching force now available for the men would be made available for

the women. There would be no duplication. There would, however, be an institutional *esprit de corps*.

2. I do not think that the policy of the college should be to inaugurate a course designed chiefly to prepare teachers of home economics. Opportunities for this sort of training are already in existence. Probably graduates of the college would enter this field, but I should think it wise to build the whole course on the idea that this outcome would be only an incident.

3. If work for women is started it ought to include at the outset some provision for investigational work. So far as food is concerned this would be partially taken care of in existing departments of the institution. But, of course, there is a vast field to be explored in lines that are of specific interest to the education of women.

4. We have for a number of years maintained effective work in the Extension Service in relation to home economics and other interests of women. This work, of course, should correlate intimately with the campus work of teaching and investigation, and should in itself be enlarged in scope and amount.

5. I have no set notions relative to the course of study that should be provided. This should be worked out by competent women on the ground. In general, however, I think the work should have for its backbone the vocational element; that it should at the same time give a large measure of attention to the humanistic or cultural subjects; and that it should also insist upon a proportion of work leading the students to an understanding of the relation of women, both as home makers and as citizens, to the needs of the community, to the State and to the nation. In other words, we should follow with the women practically the same principles of course building that we follow with the men.

Equipment.

The immediate requirements for starting this work for women would be the employment of a director of women's work, and probably at least two additional teachers. There should be provided quarters for administration and teaching. These may not be very extensive at first, but we have at present absolutely no place for even office room for such members of our faculty. As soon as possible, a women's dormitory should be erected.

I speak of these as important necessities. I do not see that we can hope for any adequate development of this work unless these minimum needs are met. Once we have the nucleus of a working corps and a place for them to work in, we will then develop adequate plans for the building of an institution as rapidly as demands are made upon us.

The Time is Opportune.

I believe that we should not longer delay the inauguration of this type of work. The students are coming to us, the percentage of attendance increasing very rapidly in spite of the fact that we offer no special encouragement. Moreover, this very war emergency that is reducing our attendance of men increases the call for special work for women. Particularly in relation to the food question as a practical contribution to the war, both in production and in conservation, we find the need for educational work.

Recommendation.

I therefore recommend that we ask the Legislature for $30,000 to be available from July 1, 1918, to June 30, 1920, for salaries and maintenance of a woman's department; also the appropriation of $70,000 for an administration building, the money to be available and the contract let when the Governor and Council have approved plans and specifications for the building and consented to its erection.

TABLES AND STATISTICS.

TABLE I. — *Resignations.*

Position.	Name.
Clerk, division of horticulture,	Eleanor Barker.
Assistant in veterinary science,	C. Theodore Buchholz.
Inventory clerk, treasurer's office,	Maude B. Chambers.
Stenographer, junior extension,	Doris Clark.
Instructor in dairying,	Samuel Coons.
Clerk, department of poultry husbandry,	Marcella P. Curry.
Telephone operator, Stockbridge Hall,	Louise G. Davidson.
Stenographer, department of dairying,	Katherine L. Fenton.
Professor of military science and tactics,	Henry W. Fleet.
Supervisor of correspondence courses,	Erwin H. Forbush.
Clerk, department of beekeeping,	Marion Guertin.
Bookkeeper, treasurer's office,	Alice E. Gustafson.
Instructor in French,	William L. Harmount.[1]
Stenographer, extension service,	Helena Keiber.
Instructor in botany,	George W. Martin.
Stenographer, department of entomology,	Helen A. Martin.
Stenographer, division of rural social science,	Nell C. Milton.
Extension instructor in agricultural education,	Ethel H. Nash.
Associate professor of floriculture,	Arno H. Nehrling.
Curator, department of botany,	Grace B. Nutting.
Assistant in English,	Philip W. Payne.
Assistant professor of animal husbandry,	Elvin L. Quaife.
Library assistant,	Vivian L. Roy.
Instructor in poultry husbandry,	Everett H. Rucker.
Instructor in agricultural economics,	Ralph M. Rutledge.
Bookkeeper, treasurer's office,	Edna M. Sanders.
Assistant to director of extension service,	Bernard W. Shaper.
Stenographer, extension service,	Elsa Slattery.
Assistant to the commandant,	Alexander Smart.
Assistant in physics,	Harry C. Thompson.
Associate professor of microbiology,	F. H. H. VanSuchtelen.
Assistant director, extension service,	Earnest D. Wald.
First clerk, treasurer's office,	Henrietta L. Webster.
Assistant professor of horticulture,	John T. Wheeler.[2]

[1] Deceased.

[2] Effective Dec. 15, 1917.

TABLE II. — *New Appointments.*

A. *In the Academic Departments.*

POSITION.	Name.	Institution from which graduated and Degrees.
Associate professor of agronomy,	Arthur B. Beaumont,	B.Sc., Kentucky State University, 1908.
Assistant professor of floriculture,	August G. Hecht,	B.Sc., University of Illinois, 1914.
Instructor in microbiology,	Egerton G. Hood,	B.S.A., Toronto University, 1913.
Assistant professor of animal husbandry.	Byron E. Pontius,	B.Sc., Ohio State University, 1914.
Instructor in poultry husbandry,	Lloyd L. Stewart,	B.Sc., Purdue University, 1915.
Instructor in dairying,	Stanley E. VanHorn,	- - -
Instructor in agricultural economics,	Otto F. Wilkinson,	B.A., Ohio State University, 1914; M.A., Ohio State University, 1915.
Professor of military science and tactics.	Richard H. Wilson,	United States Military Academy, West Point.

B. *In the Experiment Station.*

Assistant in veterinary science,	C. Theodore Buchholz,	V.M.D., University of Pennsylvania, 1917.
Assistant in agricultural economics,	Samuel H. DeVault,	A.B., Carson-Newman College, 1912; A.M., University of North Carolina, 1915.
Field pathologist, department of botany.	Webster S. Krout,	B.Sc. and M.A., Ohio State University, 1915.
Assistant chemist,	Bernard L. Peables,[1]	B.Sc., Bates College, 1917.
Assistant in entomology,	Stuart C. Vinal,	B.Sc., Massachusetts Agricultural College, 1915; M.Sc., Massachusetts Agricultural College, 1917.

C. *In the Extension Service.*

Supervisor of correspondence courses and editor of extension service publications.	L. Wayne Arny,	B.Sc., Pennsylvania State College, 1910.
Instructor in charge of poultry club work.	A. Lawrence Dean,[1]	- - -
Instructor in agricultural education,	Helen M. Norris,	Framingham Normal School.
Instructor in charge of pig club work,	Victor A. Rice,	B.Sc., N. C. A. and E. College, 1917.
Instructor in pomology,	Ralph A. VanMeter,[1]	B.Sc.Agr., Ohio State University, 1917.
Assistant to the director,	Bernard W. Shaper,	B.Sc., Cornell University, 1914.

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[1] Temporary appointment.

TABLE II. *New Appointments* — Concluded.

D. In the Clerical Staff.

POSITION.	Name.
Clerk, extension service,	Ella B. Baldwin.
Stenographer, Division of rural social science,	Bertha E. Connelly.
Telephone operator, Stockbridge Hall,	Emily Davidson.
Clerk, power plant,	Noella Duval.
Stenographer, extension service,	Margaret Evens.
Curator, department of botany,	Mae F. Holden.
Mailing clerk, extension service,	Clarence A. Kendall.
Clerk, treasurer's office,	Marion E. Kelsey.
Clerk, department of poultry husbandry,	Rachael G. Leslie.
Clerk, department of poultry husbandry,	Grace MacMullen.
Library assistant,	Marion Norton.
Stenographer, division of horticulture,	Hazel Parker.
Stenographer, department of dairying,	Frances Powers.
Clerk, department of beekeeping,	Edith Robinson.
Clerk, treasurer's office,	Elizabeth Strachan.

TABLE III. — *Change in Title of Officers of the Institution.*

NAME.	Former Title.	Present Title.
Eleanor Bishop,	Clerk, treasurer's office,	Bookkeeper, treasurer's office.
Wesley H. Bronson,	Extension instructor in farm demonstration.	Extension assistant professor of farm demonstration.
F. Ethel Felton,	Clerk, experiment station,	Clerk and editorial assistant experiment station.
Clarence E. Gordon,	Associate professor of zoölogy and geology.	Professor of zoölogy and geology.
Harold M. Gore,	Instructor in physical education,	Assistant professor of physical education.
Arao Itano,	Instructor in microbiology,	Assistant professor of microbiology.
Austin D. Kilham,	Extension instructor in pomology.	Extension assistant professor of pomology.
Alfred G. Lunn,	Extension instructor in poultry husbandry.	Extension professor of poultry husbandry.
Frederick G. Merkle,	Assistant in agronomy,	Instructor in agronomy.
Marie Sayles,	Extension instructor in home economics.	Extension assistant professor of home economics.
F. A. Cushing Smith,	Extension instructor in civic improvement.	Extension assistant professor of landscape gardening.
Ethelyn Streeter,	Stenographer, division of horticulture.	Clerk, division of horticulture.
William F. Turner,	Extension instructor in animal husbandry.	Extension assistant professor of animal husbandry.

TABLE IV. — *Leaves of Absence.*

POSITION.	Name.	Cause of Leave.
Assistant chemist, experiment station.	Windom A. Allen,	War service.
Professor of general and physical chemistry.	Ernest Anderson,	One year, from Sept. 1, 1917; at Transvaal University, South Africa.
Extension assistant professor of farm demonstration.	Wesley H. Bronson,	War service.
Professor of forestry,	William D. Clark,	With State Fuel Administrator.
Assistant in physical education,	Llewelyn L. Derby,	War service from Dec. 8, 1917.
Head of division of agriculture and professor of farm administration.	James A. Foord,	One year, from Jan. 15, 1917; sabbatical leave.
Assistant professor of physical education.	Harold M. Gore,	War service.
Field agent,	Charles H. Gould,	With Hampshire County Farm Bureau.
Professor of agricultural education,	William R. Hart,	Six months, from April 1, 1917; sabbatical leave.
Instructor in mathematics,	Burt A. Hazeltine,	War service.
Extension instructor in charge of poultry club work.	Roswell W. Henninger,	War service.
Director of extension service and supervisor of short courses.	William D. Hurd,	Ten months from Nov. 1, 1917; sabbatical leave.
Assistant in veterinary science, experiment station.	John B. Lentz,	War service.
Assistant professor of mathematics,	William L. Machmer,	Work with the United States Department of Agriculture.
Extension assistant professor of home economics.	Marie Sayles,	Work with United States Department of Agriculture.
Assistant chemist, experiment station.	Robert S. Scull,	Chemical work with government.
Assistant chemist, experiment station.	John B. Smith,	War service.
Head of division of horticulture and professor of landscape gardening.	Frank A. Waugh,	Six months, from April 1, 1917; sabbatical leave.
Extension assistant professor of landscape gardening.	F. A. Cushing Smith,	War service from Jan. 1, 1918.

TABLE V. — *Speakers for the Year.*

A. *Speakers at Wednesday Assembly for Year ending Nov. 30, 1917.*

1916.

Dec. 6. — Hon. George D. Chamberlain, Springfield, Mass.
Dec. 13. — Mr. Charles H. Gould, M. A. C.

1917.

Jan. 3. — Prof. Curry S. Hicks, M. A. C.
Jan. 10. — Mr. William C. Langdon, New York City.
Jan. 17. — Dr. W. D. Weatherford, International Y. M. C. A., Nashville, Tenn.
Jan. 24. — Pres. Kenyon L. Butterfield.
Jan. 31. — Mr. Denis A. McCarthy, Boston, Mass.
Feb. 7. — Pres. Kenyon L. Butterfield.
Feb. 14. — Mr. Joseph Novitski, M. A. C.
Feb. 21. — Hon. Marcus M. Marks, New York City.
Feb. 28. — Mr. Ralph S. Bauer, Lynn, Mass.
Mar. 7. — Capt. Henry W. Fleet, M. A. C.
Mar. 14. — Mr. George L. Farley, M. A. C.
Apr. 4. — Preparedness program: Judge Michael J. Murray, Boston, Mass.; Mr. Herbert S. Carruth, Amherst, Mass.; Mr. David H. Buttrick, M. A. C., 1917.
Apr. 11. — Prof. John T. Wheeler, M. A. C.
Apr. 18. — Prof. Robert Frost, Amherst College, Amherst, Mass.

TABLE V. — *Speakers for the Year* — Concluded.

A. Speakers at Wednesday Assembly for Year ending Nov. 30, 1917 — Concluded.

1917.
Apr. 25. — Pres. Kenyon L. Butterfield.
Oct. 24. — Prof. George G. Wilson, Harvard University, Cambridge, Mass.
Oct. 31. — Dr. Kokichi Morimoto, Johns Hopkins University, Baltimore, Md.
Nov. 7. — Student forum.
Nov. 14. — Mr. D. Brewer Eddy, Boston, Mass.
Nov. 21. — Dr. Harvey W. Wiley, Washington, D. C.

B. Speakers at Sunday Chapel for Year ending Nov. 30, 1917.

1916.
Dec. 3. — Bishop Thomas F. Davies, Springfield, Mass.
Dec. 10. — Rev. Albert C. Knudson, Boston, Mass.
Dec. 17. — Mr. Daniel A. Poling, Boston, Mass.

1917.
Jan. 7. — Mr. Charles Stelzle, New York City.
Jan. 14. — Pres. John M. Thomas, Middlebury College, Middlebury, Vt.
Jan. 21. — Dr. Sidney E. Goldstein, New York City.
Jan. 28. — Rev. Philip S. Schenck, Framingham, Mass.
Feb. 4. — Rev. F. H. Decker, Providence, R. I.
Feb. 11. — Rev. Abraham M. Rihbany, Boston, Mass.
Feb. 18. — Rev. Archibald Black, Concord, N. H.
Feb. 25. — Rev. Daniel A. Evens, Cambridge, Mass.
Mar. 4. — Bishop Edwin H. Hughes, Boston, Mass.
Mar. 11. — Mr. Owen R. Lovejoy, New York City.
Mar. 18. — Pres. W. H. P. Faunce, Brown University, Providence, R. I
Apr. 8. — Mr. Thomas Mott Osborne, Auburn, N. Y.
Apr. 15. — Rev. Harold Marshall, Melrose, Mass.
Apr. 22. — Dr. Ernest Abbott, New York City.
Apr. 29. — Rev. Nehemiah Boynton, Brooklyn, N. Y.

TABLE VI. — *Attendance.*

A. In Work of College Grade.

	Registration Nov. 30, 1916.	Registration Nov. 30, 1917.
Senior class,	104	64
Junior class,	138	113
Sophomore class,	174	117
Freshman class,	159	108
Probationary freshmen,	11	10
	586	412
Graduate students,	57	29
Unclassified students,	29	50
Vocational poultry students,	8	5
Special students,	–	4
	680	500

TABLE VI. — *Attendance* — Concluded.

B. Short-course Enrollment and Convention Registration.

	1916.	1917.
Winter school,	153	110
Farmers' week,	980	800
Beekeepers' school,	10	50
Polish farmers' day,	220	300
Apple packing school,	8	–
County agents' conference,	55	120
Bankers' conference,	28	–
Summer school of agriculture and country life,	170	90
Conference on rural organization,	38	121
School for rural social service,	35	20
Ministers' conference,	–	8
Poultry convention,	268	176
Boys' camps,	88	102
Girls' camp,	27	17
	2,080	1,914

TABLE VII. — *Legislative Budget, 1917.*

ITEMS.	Amount asked.	Amount granted.
Library and equipment,	$250,000	–
Equipment and improvements,	75,000	$33,500
Poultry building,	4,200	–
Student dormitory,	50,000	–
Dining hall improvements,	10,000	–
Rural engineering shops,	9,000	–
Power plant, turbine house and steam line tunnels,	90,000	40,000
	$488,200	$73,500
Buildings, equipment and maintenance for market-garden field station,	$35,000	$10,000
Emergency appropriation for current expenses,	$25,000	$17,500

Table VIII. — *Statistics of Freshmen entering Massachusetts Agricultural College, October, 1917.*

A. Home Addresses of Students (classified by Towns and Cities).

Amesbury,	1
Amherst,	7
Arlington,	3
Atlanta, Ga.,	1
Bernardston,	1
Bethel, Conn.,	1
Boston,	8
Brockton,	2
Brookline,	2
Brooklyn, N. Y.,	1
Cambridge,	1
Charlemont,	1
Chatham, N. J.,	1
Chester,	1
Chicopee,	1
Deerfield,	1
Easthampton,	1
Easton,	2
Enfield,	1
Fall River,	1
Far Rockaway, N. J.,	1
Fitchburg,	1
Great Barrington,	1
Hadley,	2
Hartford, Conn.,	1
Haverhill,	1
Hopedale,	1
Jefferson,	1
Lexington,	1
Lynn,	7
Malden,	3
Marshfield,	1
Maynard,	1
Medfield,	1
Medford,	1
Melrose,	2
Millis,	1
Nampa, Idaho,	1
Natick,	1
Needham,	2
New Bedford,	1
Newport, R. I.,	1
New Rochelle, N. Y.,	1
New York City, N. Y.,	1
Northampton,	1
Oakham,	1
Orange,	1
Palmer,	1
Peabody,	3
Providence, R. I.,	1
Reading,	1
Rockland,	1
Rowley,	1
Salem,	1
Shelburne,	2
Somerset,	1
Somerville,	4
South Meriden, Conn.,	1
Springfield,	4
Stoneham,	1
Sturbridge,	1
Sutton,	1
Templeton,	1
Topsfield,	1
Washington, D. C.,	1
Webster,	1
Westborough,	1
Westfield,	1
West Haven, Conn.,	1
Weymouth,	2
Whitman,	1
Williamsburg,	1
Williamstown,	1
Willimantic, Conn.,	1
Winchendon,	1
Winthrop,	2
Worcester,	2

B. Home Addresses (classified by States).

	Number.	Per Cent.		Number.	Per Cent.
Connecticut,	5	4.23	New Jersey,	2	1.69
District of Columbia,	1	.85	New York,	3	2.54
Georgia,	1	.85	Rhode Island,	2	1.69
Idaho,	1	.85		118	99.99
Massachusetts,	103	87.29			

C. Home Addresses (classified by Counties of Massachusetts).

	Number.	Per Cent.		Number.	Per Cent.
Berkshire,	2	1.94	Middlesex,	19	18.45
Bristol,	5	4.85	Norfolk,	8	7.77
Essex,	15	14.56	Plymouth,	5	4.85
Franklin,	6	5.83	Suffolk,	10	9.71
Hampden,	8	7.77	Worcester,	12	11.65
Hampshire,	13	12.62		103	100.00

TABLE VIII. — *Statistics of Freshmen entering Massachusetts Agricultural College, October, 1917* — Continued.

D. Nativity of Parents.

	Number.	Per Cent.
Neither parent foreign born,	85	72.03
Both parents foreign born,	24	20.33
Father (only) foreign born,	3	2.54
Mother (only) foreign born,	6	5.09
	118	99.99

E. Education of Father.

	Number.	Per Cent.
Common school,	45	38.13
High school,	41	34.75
Business school,	13	11.02
College or university,	16	13.56
No statistics,	3	2.54
	118	100.00

F. Religious Census.

	MEMBERSHIP.		PREFERENCE.		TOTALS.	
	Number.	Per Cent.	Number.	Per Cent.	Number.	Per Cent.
Baptist,	7	5.93	5	4.24	12	10.17
Catholic,	7	5.93	1	.85	6	6.78
Congregationalist,	28	23.73	14	11.86	42	35.59
Episcopal,	9	7.63	1	.85	10	8.47
Hebrew,	5	4.24	–	–	5	4.24
Methodist,	11	9.32	1	.85	12	10.17
Presbyterian,	3	2.54	–	–	3	2.54
Unitarian,	6	5.09	2	1.70	8	6.78
Universalist,	3	2.54	3	2.54	6	5.09
Miscellaneous,	6	5.09	5	4.24	11	9.32
No statistics,	–	–	–	–	1	.85
	85	72.03	32	27.12	118	100.00

TABLE VIII. — *Statistics of Freshmen entering Massachusetts Agricultural College, October, 1917* — Concluded.

G. Occupation of Father.

	Number.	Per Cent.
Agriculture and horticulture,	24	20.33
Artisans,	30	25.42
Business,	36	30.51
Deceased or no statistics,	8	6.78
Miscellaneous,	11	9.32
Professional,	9	7.63
	118	99.99

H. Intended Vocation of Student.

	Number.	Per Cent.
Agriculture or horticulture (practical),	53	44.92
Agriculture or horticulture (professional),	43	36.44
Miscellaneous,	1	.85
Professions,	3	2.54
Undecided or no statistics,	18	15.25
	118	100.00

I. Farm Experience.

	Number.	Per Cent.
Brought up on a farm,	34	28.81
Not brought up on a farm and having had no or practically no farm experience.	23	19.49
Not brought up on a farm but having had some farm experience.	61	51.70
	118	100.00

J. Miscellaneous Statistics.

Average age,	19.08 years.
Number signifying their intention to seek student labor,	73 (61.86 per cent.).
Number boarding at the college dining hall,	63 (53.39 per cent.).

TABLE IX. — *Entrance Statistics of Freshman Class.*

Number of applications (preliminary applications number 41),			197
Admitted,		130	
Matriculated,	108		
Allowed probationary entrance,	10		
Failed to report,	22		
Rejected,		67	
Total,			197
Matriculated on certificate,			43
Matriculated on certificate and examination,			49
Matriculated on examination,			3
Matriculated on credentials from other colleges,			5
Matriculated on regents' credentials,			2
Re-entered,			6
Entered on probation,			10
Total,			118
Entered with conditions,			51
Entered without conditions,			67
Total,			118

TABLE X. — *Cases treated at the Infirmary, Dec. 1, 1916, to Nov. 30, 1917.*

	Daily Count.	Individual Count.
December 1, 1916, to January 1, 1917: —		
House cases,	4	1
Out-patients,	31	31
January 1 to February 1: —		
House cases,	31	6
Out-patients,	47	41
February 1 to March 1: —		
House cases,	20	6
Out-patients,	83	38
March 1 to April 1: —		
House cases,	38	7
Out-patients,	107	36
April 1 to May 1: —		
House cases,	141	22
Out-patients,	65	37
May 1 to June 3: —		
House cases,	45	4
Out-patients,	15	4
June 3 to June 15: —		
House cases,	9	1
Out-patients,	-	-
October 10 to November 1: —		
House cases,	27	4
Out-patients,	30	17
November 1 to December 1: —		
House cases,	43	7
Out-patients,	77	26

TABLE X. — *Cases treated at the Infirmary, Dec. 1, 1916, to Nov. 30, 1917* — Concluded.

Number of house cases,	358
Number of out-patients,	455
Total,	813
Number cared for in the house,	58
Number cared for as out-patients,	230
Total,	288

REPORT OF THE TREASURER

FOR THE FISCAL YEAR ENDING NOV. 30, 1917.

BALANCE SHEET.

		DR.	CR.
1916.			
Dec. 1.	To balance on hand,	$41,854 54	
1917.			
Nov. 30.	To receipts for fiscal year,	656,653 90	
	Expenditures for fiscal year,		$675,746 92
	Balance on hand,		22,761 52
		$698,508 44	$698,508 44

SCHEDULE A. — INCOME.

		Items.	Totals.
Income from students and others,			$96,972 93
Tuition,		$2,845 00	
Laboratory fees,		7,517 75	
Rents,		5,538 73	
Department sales,		69,052 87	
Department transfers,		6,430 90	
Miscellaneous,		5,587 68	
Income from grants by nation and State: —			
State aid,			434,296 47
Income from endowment,		$3,313 32	
Appropriation for current expenses,		273,500 00	
Administration,	$39,000 00		
Maintenance,	[1] 121,500 00		
Instruction,	105,000 00		
Graduate school,	3,000 00		
Additional land,	5,000 00		
Appropriation for extension service,		50,000 00	
Appropriation for experiment station,		41,000 00	
Maintenance,	$35,000 00		
Feed law,	6,000 00		
Receipts from special appropriation,		66,483 15	
Federal aid,			87,227 51
Income from land grant of 1862,		$7,300 00	
Income from Hatch fund of 1887,		15,000 00	
Income from Adams fund of 1906,		15,000 00	
Income from Morrill fund of 1890,		16,666 67	
Income from Nelson fund of 1907,		16,666 66	
Income from Smith-Lever fund of 1914,		16,594 18	

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[1] $17,500 of this amount granted as emergency maintenance appropriation.

SCHEDULE A. — INCOME — *Concluded.*

	Items.	Totals.
Income from other sources: —		
Income from experiment station,	. . .	$30,826 61
Fertilizer receipts,	$9,040 00	
Agricultural receipts,	4,810 22	
Cranberry receipts,	3,172 02	
Chemical receipts,	11,939 54	
Miscellaneous receipts,	1,864 83	
Income from extension service,	. . .	7,330 38
Winter school,	$480 00	
Summer school,	3,058 68	
Correspondence courses receipts,	661 64	
Exhibits,	575 00	
Civic improvements,	340 91	
Miscellaneous receipts,	2,214 15	
Total,	$656,653 90	$656,653 90

Classification of Income from Students and Others.

	Laboratory Fees.	Department Sales.	Transfers.	Rent.	Miscellaneous.	Tuition.	Totals.
Agricultural education,	-	-	-	-	$10 70	-	$10 70
Agronomy,	$432 50	$37 80	$10 80	-	-	-	481 10
Animal husbandry,	276 50	-	-	-	2 46	-	278 96
Beekeeping,	-	463 00	4 83	-	-	-	467 83
Botany,	1,077 50	15 29	4 30	$15 43	-	-	1,112 52
Chemistry,	2,632 00	12 56	3 05	-	160 85	-	2,808 46
Dairying,	268 00	20,397 31	786 44	-	-	-	21,451 75
Entomology,	99 00	27 44	-	-	-	-	126 44
Farm administration,	139 00	28 02	36	-	3 67	-	171 05
Floriculture,	169 25	3,333 92	40 41	-	-	-	3,543 58
Farm,	-	27,570 28	3,432 65	-	-	-	31,002 93
Forestry,	50 00	-	33 00	-	26 00	-	109 00
Freshman agriculture,	115 00	-	-	-	-	-	115 00
General agriculture,	-	-	11	-	12 15	-	12 26
General horticulture,	-	2,006 77	1,997 63	-	288 83	-	4,293 23
Graduate school,	3 00	-	-	-	-	-	3 00
Grounds,	-	-	40 04	-	69 53	-	109 57
Hospital,	-	-	-	-	90 00	-	90 00
Landscape gardening,	263 00	3 73	2 24	-	-	-	268 97
Language and literature,	232 00	-	-	-	-	-	232 00

CLASSIFICATION OF INCOME FROM STUDENTS AND OTHERS — *Concluded.*

	Laboratory Fees.	Department Sales.	Transfers.	Rent.	Miscellaneous.	Tuition.	Totals.
Library,	-	$34 74	-	-	$466 36	-	$501 10
Market gardening,	$104 00	2,715 25	$66 19	-	-	-	2,885 44
Mathematics,	107 75	-	-	-	-	-	107 75
Microbiology,	322 50	-	1 50	-	323 50	-	647 50
Military,	-	-	-	-	4 40	-	4 40
Miscellaneous,	-	-	-	-	157 00	-	157 00
Physics,	63 00	-	-	$9 00	-	-	72 00
Pomology,	102 00	1,986 68	80	-	-	-	2,089 48
Poultry husbandry,	158 50	10,258 76	4 90	-	-	-	10,422 16
Rural engineering,	350 25	10 00	-	-	7 21	-	367 46
Veterinary,	35 00	55 14	-	-	-	-	90 14
Zoölogy and geology,	518 00	-	-	-	-	-	518 00
War emergency,	-	81 55	-	-	-	-	81 55
Operating and maintenance,	-	-	-	-	3,954 52	$2,845 00	6,799 52
North dormitory,	-	-	-	1,579 67	-	-	1,579 67
South dormitory,	-	-	-	2,257 17	-	-	2,257 17
College residence,	-	-	-	583 21	-	-	583 21
President's office,	-	14 63	1 65	-	-	-	16 28
Executive order,	-	-	-	-	10 50	-	10 50
Draper Hall,	-	-	-	1,094 25	-	-	1,094 25
Totals,	$7,517 75	$69,052 87	$6,430 90	$5,538 73	$5,587 68	$2,845 00	$96,972 93

SCHEDULE B. — EXPENDITURES FOR FISCAL YEAR.

	Items.	Totals.
College expenses,	. . .	$416,399 99
Administration,	$35,956 38	
Maintenance,	229,531 36	
Instruction,	150,912 25	
Experiment station,	. . .	101,661 67
Administration,	$1,234 51	
Feed inspection,	6,772 57	
Fertilizer law,	9,287 40	
Salaries,	45,271 80	
Department,	39,095 39	
Extension service,[1]	. . .	81,952 97
Salaries,	$48,097 39	
Travel,	13,009 99	
Departments,	20,845 59	
Special appropriation,	. . .	75,732 29
1914, agricultural building,	$140 11	
1915, microbiology building,	2,760 66	
1916, improvements and equipment,	2,663 23	
1916, rural engineering shop,	2,379 90	
1916, market-garden field station,	7,968 52	
1916, Mount Toby demonstration forest,	30,000 00	
1917, improvements and equipment,	15,218 12	
1917, market-garden field station,	6,825 86	
1917, power plant improvements,	7,417 71	
Special architect,	358 18	
Total,	$675,746 92	$675,746 92

[1] Made up from State extension service and Smith-Lever funds.

Analysis of College Expenditures.

Administration.	Office Expense.	Salaries and Labor.	Travel.	Minor Equipment.	Building Supplies.	Publicity and Lectures.	Student Activity.	Commencement.	Miscellaneous.	Totals.
Dean's office,	$297 50	$262 24	-	$4 36	-	-	-	-	-	$564 10
Executive order,	-	-	$1,899 77	-	-	$1,452 61	$572 50	$137 36	$2,107 58	6,169 82
President's office,	968 19	155 42	49 42	45 00	$1 97	-	-	-	110 99	1,330 99
Registrar's office,	482 95	52 30	53 24	2 43	-	-	-	-	-	590 92
Treasurer's office,	578 76	322 23	145 60	6 41	8 40	-	-	-	18 61	1,080 01
Administration (salaries),	-	26,220 54	-	-	-	-	-	-	-	26,220 54
Totals,	$2,327 40	$27,012 73	$2,148 03	$58 20	$10 37	$1,452 61	$572 50	$137 36	$2,237 18	$35,956 38

Maintenance.	Office Supplies.	Labor.	Laboratory Supplies.	Refunds.	Minor Equipment.	Building Supplies.	Travel.	General Expense.	Miscellaneous.	Salaries.	Totals.
Academic maintenance: —											
Agricultural economics,	$126 66	$38 10	$15 40	-	$4 67	-	$39 29	-	-	-	$224 12
Agricultural education,	124 89	11 32	5 67	-	-	-	64 69	-	-	-	206 57
Agronomy,	196 88	115 98	211 89	$155 50	99 26	-	25 65	-	-	-	805 16
Animal husbandry,	112 84	70 09	114 50	4 50	15 10	-	271 88	-	-	-	588 91
Beekeeping,	110 44	1,114 62	254 80	-	294 67	$58 26	32 40	-	-	-	1,865 19
Botany,	190 02	514 81	421 21	187 25	33 56	68 83	-	-	-	-	1,415 68
Chemistry,	133 65	932 63	2,773 24	697 23	39 77	63 20	-	-	-	-	4,639 72
Dairying,	165 94	2,963 35	22,061 36	63 04	566 24	93 32	93 35	-	-	-	26,006 60
Economics and sociology,	10 43	-	20 02	-	15 37	-	-	-	-	-	45 82
Entomology,	97 33	215 10	77 42	16 25	28	111 45	-	-	-	-	517 83
Farm administration,	122 44	51 92	75 34	24 00	5 21	-	6 57	-	-	-	285 48
Floriculture,	93 40	4,460 78	1,339 54	36 25	23 66	93 10	72 84	-	-	-	6,119 57
Forestry,	18 00	66 16	26 19	3 00	127 14	-	43 50	-	-	-	283 99
Freshman agriculture,	-	85	15 69	4 00	-	-	-	-	-	-	20 54
General agriculture,	-	1,144 79	-	-	70 95	185 72	-	$137 75	$0 45	-	1,539 66

History and government,	3 38	-	65	-	-	-	-	-	-	-	4 03
Hospital,	-	1,317 08	-	-	88 81	-	-	442 36	-	-	1,848 25
Landscape gardening,	17 42	42	278 30	41 50	6 79	-	-	-	-	-	344 43
Language and literature,	44 78	85 26	118 81	34 00	4 57	-	-	-	-	-	287 42
Market gardening,	116 70	2,873 99	922 75	24 50	2 46	4 08	171 94	-	-	-	4,116 42
Mathematics,	62 15	65 75	10 33	41 00	14 75	21 47	-	-	-	-	215 45
Microbiology,	151 33	374 81	504 08	141 98	145 45	99 39	-	-	-	-	1,417 04
Military science,	178 68	504 48	144 30	-	461 87	66 72	-	165 19	-	-	1,521 24
Mount Toby,	-	26 00	-	-	-	-	7 70	13 26	6 00	-	52 96
Physical education,	64 65	215 91	349 06	-	-	86 61	164 42	-	-	-	880 65
Physics,	49 28	206 36	129 01	52 45	66 43	19 41	4 18	-	-	-	527 12
Pomology,	142 80	2,505 82	669 47	2 75	51 24	-	30 46	-	-	-	3,402 54
Poultry husbandry,	632 75	2,600 65	10,945 77	30 25	184 66	87 39	59 21	-	-	-	14,540 68
Rural engineering,	41 87	109 46	286 41	39 75	79 61	22 79	3 85	-	-	-	583 74
Rural sociology,	86 58	27 99	7 13	-	-	-	28 02	-	-	-	149 72
Veterinary science,	64 49	260 35	699 89	6 00	3 59	41 99	-	-	-	-	1,076 31
Zoölogy and geology,	26 67	101 60	200 82	85 50	90 60	4 77	17 64	-	-	-	527 60
War emergency,	-	819 16	-	-	-	-	-	720 46	70	-	1,540 32
1917, celebration,	-	69 38	-	-	-	-	69 52	459 34	8 43	$1,500 00	2,106 67
General maintenance: —											
Equipment,	-	-	-	-	-	-	-	3,604 43	-	-	3,604 43
Farm,	-	-	-	-	-	-	-	42,767 91	-	-	42,767 91
General horticulture,	253 43	5,783 63	80 48	-	81 58	-	-	1,664 46	321 70	-	8,185 28
Graduate school,	33 55	-	-	-	-	-	-	240 00	-	-	273 55
Grounds,	-	3,813 67	-	-	132 66	-	-	272 83	141 52	-	4,360 68
Land,	-	-	-	-	-	-	-	7,200 00	-	-	7,200 00
Library,	543 34	561 53	-	-	82 26	-	102 22	5,555 64	-	-	6,844 99
Operating and maintenance,	-	-	-	-	-	-	-	76,587 09	-	-	76,587 09
Totals,	$4,016 77	$34,023 80	$42,759 53	$1,690 70	$2,793 21	$1,128 50	$1,309 33	$139,830 72	$478 80	$1,500 00	$229,531 36
Instruction (salaries),	-	-	-	-	-	-	-	-	-	$150,912 25	$150,912 25
Grand total,	-	-	-	-	-	-	-	-	-	-	$416,399 99

CURRENT ACCOUNTS.

Disbursements and Receipts.

ACCOUNTS.	Disbursements from Nov. 30, 1916, to Nov. 30, 1917.	Receipts from Nov. 30, 1916, to Nov. 30, 1917.	Apportionment for Year ending Nov. 30, 1917.	Balance to Credit.
Administration: —				
Dean's office,	$564 10	-	$600 00	$35 90
Executive order,	6,169 82	$10 50	7,800 00	1,640 68
President's office,	1,330 99	16 28	1,250 00	—64 71
Registrar's office,	590 92	-	600 00	9 08
Salaries,	26,220 54	-	28,000 00	1,779 46
Treasurer's office,	1,080 01	-	1,000 00	—80 01
State Treasurer,	-	39,000 00	-	-
Maintenance, academic: —				
Agricultural economics,	224 12	-	200 00	—24 12
Agricultural education,	206 57	10 70	500 00	304 13
Agronomy,	805 16	481 10	450 00	125 94
Animal husbandry,	588 91	278 96	400 00	90 05
Beekeeping,	1,865 19	467 83	1,500 00	102 64
Botany,	1,415 68	1,112 52	800 00	496 84
Chemistry,	4,639 72	2,808 46	2,000 00	168 74
Dairying,	26,006 60	21,451 75	5,000 00	445 15
Economics and sociology,	45 82	-	50 00	4 18
Entomology,	517 83	126 44	750 00	358 61
Farm administration,	285 48	171 05	250 00	135 57
Floriculture,	6,119 57	3,543 58	2,740 00	164 01
Forestry,	283 99	109 00	375 00	200 01
Freshman agriculture,	20 54	115 00	-	94 46
General agriculture,	1,539 66	12 26	1,500 00	—27 40
History and government,	4 03	-	25 00	20 97
Hospital,	1,848 25	90 00	1,700 00	—58 25
Landscape gardening,	344 43	268 97	-	—75 46
Language and literature,	287 42	232 00	350 00	294 58
Market gardening,	4,116 42	2,885 44	1,600 00	369 02
Mathematics,	215 45	107 75	150 00	42 30
Microbiology,	1,417 04	647 50	1,200 00	430 46
Military science,	1,521 24	4 40	1,450 00	—66 84
Mount Toby,	52 96	-	500 00	447 04
Physical education,	880 65	-	700 00	—180 65
Physics,	527 12	72 00	600 00	144 88
Pomology,	3,402 54	2,089 48	1,875 00	561 94
Poultry husbandry,	14,540 68	10,422 16	2,800 00	—1,318 52
Rural engineering,	583 74	367 46	400 00	183 72
Rural sociology,	149 72	-	175 00	25 28
Veterinary science,	1,076 31	90 14	1,300 00	313 83
War emergency,	1,540 32	81 55	-	—1,458 77
Zoölogy and geology,	527 60	518 00	333 00	323 40
1917 celebration,	2,106 67	-	5,000 00	2,893 33
Maintenance, general: —				
Equipment,	3,604 43	-	-	—3,604 43
Farm,	42,767 91	31,002 93	3,500 00	—8,264 98
General horticulture,	8,185 28	4,293 23	4,000 00	107 95
Graduate school,	273 55	3 00	400 00	129 45
Grounds,	4,360 68	109 57	4,900 00	648 89
Library,	6,844 99	501 10	6,560 00	216 11
Operating and maintenance,	76,587 09	12,313 82	59,040 00	—17,547 09
State Treasurer, maintenance,	-	121,500 00	-	-
Land,	7,200 00	5,000 00	1,650 00	—550 00
Endowment fund,	-	10,613 32	-	-
Instruction: —				
Salaries,	150,912 25	157 00	157,000 00	6,244 75
United States Treasurer, Morrill fund,	-	16,666 67	-	-
United States Treasurer, Nelson fund,	-	16,666 66	-	-
State Treasurer, instruction,	-	105,000 00	-	-
Graduate school,	-	3,000 00	-	-
Totals,	$416,399 99	$414,419 58	$312,973 00	-
Balance beginning fiscal year Dec. 1, 1916,	-	19,696 41	-	-
Balance on hand Nov. 30, 1917,	17,716 00	-	-	-
Totals,	$434,115 99	$434,115 99	-	-

COLLEGE ACCOUNTS.

Comparative Disbursements and Receipts for 1916–17.

ACCOUNTS.	DISBURSEMENTS.		RECEIPTS.	
	1916.	1917.	1916.	1917.
Agricultural economics,	$228 28	$224 12	$21 00	–
Agricultural education,	493 27	206 57	70 00	$10 70
Agronomy,	738 69	805 16	137 75	481 10
Animal husbandry,	398 51	588 91	280 88	278 96
Beekeeping,	1,682 36	1,865 19	288 05	467 83
Botany,	1,490 06	1,415 68	1,123 95	1,112 52
Chemistry,	5,019 78	4,639 72	2,551 16	2,808 46
Dairying,	24,845 24	26,006 60	20,678 17	21,451 75
Dean's office,	529 78	564 10	–	–
Economics and sociology,	39 61	45 82	–	–
Entomology,	615 75	517 83	91 26	126 44
Equipment,	1,789 65	3,604 43	–	–
Executive order,	8,421 77	6,169 82	37 88	10 50
Farm administration,	394 84	285 48	102 05	171 05
Farm,	35,143 56	42,767 91	28,986 93	31,002 93
Floriculture,	6,320 55	6,119 57	3,517 05	3,543 58
Forestry,	314 48	283 99	10 50	109 00
Freshman agriculture,	–	20 54	–	115 00
General agriculture,	1,610 14	1,539 66	124 64	12 26
General horticulture,	8,586 92	8,185 28	4,067 29	4,293 23
Graduate school,	134 61	273 55	2 00	3 00
Grounds,	5,092 93	4,360 68	25 32	109 57
History and government,	1 40	4 03	–	–
Hospital,	1,209 06	1,848 25	25 73	90 00
Improvements,	2,001 47	–	670 06	–
Land,	8,350 00	7,200 00	–	5,000 00
Landscape gardening,	388 94	344 43	254 92	268 97
Language and literature,	368 86	287 42	46 25	232 00
Library,	7,269 08	6,844 99	540 46	501 10
Market gardening,	3,620 35	4,116 42	2,144 94	2,885 44
Mathematics,	204 37	215 45	65 00	107 75
Military,	1,598 58	1,521 24	44 23	4 40
Microbiology,	1,177 81	1,417 04	446 93	647 50
Miscellaneous,	5,434 41	–	2,881 15	–
Mount Toby,	–	52 96	–	–
Physical education,	1,020 96	880 65	98 50	–
Physics,	659 80	527 12	14 96	72 00
Pomology,	3,411 79	3,402 54	1,652 05	2,089 48
Poultry husbandry,	9,403 41	14,540 68	6,470 41	10,422 16
President's office,	1,107 51	1,330 99	–	16 28
Registrar's office,	578 92	590 92	–	–
Rural engineering,	660 07	583 74	215 23	367 46
Rural sociology,	129 99	149 72	1 59	–
Salaries,	167,564 58	177,132 79	–	157 00
Treasurer's office,	1,070 76	1,080 01	–	–
Veterinary science,	1,339 60	1,076 31	22 32	90 14
Zoölogy and geology,	555 17	527 60	449 18	518 00
War emergency,	–	1,540 32	–	81 55
1917 celebration,	–	2,106 67	–	–
Operating and maintenance,	71,665 52	76,587 09	15,915 50	12,313 82
State Treasurer: —				
Endowment fund,	–	–	10,613 32	10,613 32
Graduate school,	–	–	3,000 00	3,000 00
Maintenance,	–	–	107,000 00	121,500 00
Instruction,	–	–	100,000 00	105,000 00
Administration,	–	–	35,000 00	39,000 00
United States Treasurer: —				
Morrill fund,	–	–	16,666 66	16,666 67
Nelson fund,	–	–	16,666 67	16,666 66
Totals,	$394,683 19	$416,399 99	$383,021 94	$414,419 58
Balance beginning fiscal year,	–	–	31,357 66	19,696 41
Balance on hand at close of fiscal year,	19,696 41	17,716 00	–	–
Totals,	$414,379 60	$434,115 99	$414,379 60	$434,115 99

College Accounts — *Concluded.*

Summary.

	Disbursements.	Receipts.
Cash on hand Dec. 1, 1916,		$19,696 41
Institution receipts Nov. 30, 1917,		96,972 93
State Treasurer's receipts Nov. 30, 1917,		284,113 32
United States Treasurer's receipts Nov. 30, 1917,		33,333 33
Total disbursements,	$416,399 99	-
	$416,399 99	$434,115 99
Bills receivable Dec. 1, 1916, deducted,		8,077 39
Bills payable Dec. 1, 1916, deducted,	6,250 83	
	$410,149 16	$426,038 60
Bills receivable Nov. 30, 1917,	-	10,034 55
Bills payable Nov. 30, 1917,	3,781 30	-
Balance,	22,142 69	-
	$436,073 15	$436,073 15

FARM DISBURSEMENTS.

	Labor.	Equipment.	Feed.	Fertilizer.	Seeds.	Supplies.	Improvements.	Totals.
Cattle,	$6,520 52	-	$9,149 80	-	-	$681 05	-	$16,351 37
Dairy,	2,178 19	$541 52	-	-	-	2,795 40	-	5,515 11
Horses,	2,070 47	-	2,863 72	-	-	448 12	-	5,382 31
Sheep,	239 89	-	529 02	-	-	20 60	-	789 51
Swine,	810 85	-	1,735 29	-	-	102 50	-	2,648 64
Field crops,	5,119 63	-	-	$1,038 61	$732 54	52 97	-	6,943 75
Miscellaneous,	1,793 50	-	-	-	-	125 56	$2,265 56	4,184 62
Tools and machinery,	-	-	-	-	-	952 60	-	952 60
Live stock,	-	-	-	-	-	-	-	-
Totals,	$18,733 05	$541 52	$14,277 83	$1,038 61	$732 54	$5,178 80	$2,265 56	$42,767 91

FARM CREDITS.

	Onions.	Milk.	Stock.	Sundry.	Hay.	Roots.	Labor.	Potatoes.	Totals.
Cattle,	-	$16,287 07	$2,223 85	$195 17	-	-	-	-	$18,706 09
Dairy,	-	6,299 34	-	124 74	-	-	-	-	6,424 08
Horses,	-	-	453 50	913 71	-	-	-	-	1,367 21
Sheep,	-	-	246 36	185 56	-	-	-	-	431 92
Swine,	-	-	2,445 22	4 00	-	-	-	-	2,449 22
Field crops,	$305 50	-	-	-	$77 92	$1 79	-	$282 93	668 14
Miscellaneous,	-	-	-	332 82	-	-	$623 45	-	956 27
Totals,	$305 50	$22,586 41	$5,368 93	$1,756 00	$77 92	$1 79	$623 45	$282 93	$31,002 93

AGRICULTURAL DIVISION.

Disbursements and Receipts.

	Disbursements.	Receipts.
Agronomy,	$805 16	$481 10
Animal husbandry,	588 91	278 96
Dairying,	26,006 60	21,451 75
Farm,	42,767 91	31,002 93
Farm administration,	285 48	171 05
Poultry husbandry,	14,540 68	10,422 16
Rural engineering,	583 74	367 46
Division totals,	$85,578 48	$64,175 41

Summary.

	Dr.	Cr.
By total division receipts,		$64,175 41
By bills receivable,		7,287 68
By net apportionment,		12,800 00
To total disbursements,	$85,578 48	
To bills payable,	2,324 32	
Balance,		3,639 71
	$87,902 80	$87,902 80

Inventory of Quick Assets.

	Nov. 30, 1916.	Nov. 30, 1917.
Inventory of produce,	$8,533 40	$12,668 84
Inventory of cattle,	14,200 00	17,485 00
Inventory of swine,	1,505 00	1,495 00
Inventory of horses,	6,765 00	6,440 00
Inventory of poultry,	2,277 00	2,531 75
Inventory of sheep,	668 00	1,013 00
	$33,948 40	$41,633 59

HORTICULTURAL DIVISION.

Disbursements and Receipts.

	Disbursements.	Receipts.
Floriculture,	$6,119 57	$3,543 58
Forestry,	283 99	109 00
General horticulture,	8,185 28	4,293 23
Grounds,	4,360 68	109 57
Landscape gardening,	344 43	268 97
Market gardening,	4,116 42	2,885 44
Pomology,	3,402 54	2,089 48
Division totals,	$26,812 91	$13,299 27

HORTICULTURAL DIVISION — *Concluded.*

Summary.

	DR.	CR.
By total division receipts,		$13,299 27
By bills receivable,		1,363 72
By net apportionment,		15,490 00
To total division disbursement,	$26,812 91	
To bills payable,	129 22	
By balance,	3,210 86	
	$30,152 99	$30,152 99

Inventory of Quick Assets.

	Nov. 30, 1916.	Nov. 30, 1917.
Floriculture,	$500 00	$1,200 00
Market gardening,	150 00	917 50
Pomology,	575 00	419 00
General horticulture (live stock),	1,750 50	1,810 00
	$2,975 50	$4,346 50

Expense Operating and Maintenance.

	Salaries.	Labor.	Fuel and Water.	Repairs.	Supplies.	Tools.	Architect.	Engineer.	Miscellaneous.	Totals.
General: —										
General superintendent,	$2,319 97	–	–	–	–	–	–	–	–	$2,319 97
Office,	–	$771 37	–	–	–	–	–	–	–	771 37
General expense,	–	–	–	–	$5,284 67	–	–	–	–	5,284 67
Power plant: —										
Heat,	–	6,745 03	$41,216 83	$694 26	48 02	–	–	–	–	48,704 14
Light,	–	1,069 61	8 72	185 95	60 71	–	–	–	–	1,324 99
Tools,	–	–	–	–	–	$688 85	–	–	–	688 85
Gas mains,	–	2 77	–	–	–	–	–	–	–	2 77
Amherst Water Company,	–	–	2,100 27	–	–	–	–	–	–	2,100 27
Night watchman,	–	1,426 01	–	–	–	–	–	–	–	1,426 01
Mail service,	–	407 90	–	–	–	–	–	–	–	407 90
Water mains,	–	65 97	–	–	–	–	–	–	–	65 97
Steam mains,	–	462 99	–	–	–	–	–	–	–	462 99
Electric light circuit,	–	188 93	–	–	–	–	–	–	–	188 93
Waiting station,	–	1 02	–	–	–	–	–	–	–	1 02
Miscellaneous sundry,	–	–	–	–	–	–	–	–	$2,724 70	2,724 70
Sewers and cesspools,	–	62 42	–	–	–	–	–	–	–	62 42
Walks,	–	12 52	–	–	–	–	–	–	–	12 52
Emergency maintenance,	–	767 66	–	–	–	–	–	–	–	767 66
Expert service,	–	–	–	–	–	–	$1,064 84	$825 57	101 40	1,991 81
Fire department,	–	12 99	–	–	70 73	–	–	–	–	83 72
Totals,	$2,319 97	$11,997 19	$43,325 82	$880 21	$5,464 13	$688 85	$1,064 84	$825 57	$2,826 10	$69,392 68

EXPENSE OPERATING AND MAINTENANCE — *Continued.*

	Electric Repairs.	Plumbing Repairs.	Heat Repairs.	C. and M. Repairs.	Janitor.	Bell Ringing.	Sundry.	Totals.
College buildings: —								
Animal husbandry building,	-	$4 70	$25 31	$1 69	-	-	-	$31 70
Horse barn,	$1 35	66	5 52	21 26	-	-	-	28 79
Dairy barn,	3 34	19 55	9 26	20 26	-	-	-	52 41
Young stock barn,	-	-	-	6 69	-	-	-	6 69
Power building,	32 11	1 43	16 20	62 43	$190 52	-	-	302 69
Chemical building,	6 70	72 69	10 25	257 82	-	-	-	347 46
Poultry building,	3 72	6 28	5 59	32 79	-	-	-	48 38
Dairy building,	21 33	113 60	88 51	214 20	-	-	-	437 64
Drill hall,	90	51 82	5 18	122 01	-	-	-	179 91
Veterinary building,	58	1 18	7 91	1 10	-	-	-	10 77
Apiary building,	5 66	3 56	5 31	10 91	-	-	-	25 44
Mathematics building,	86	26 72	37 12	141 66	-	-	-	206 36
Entomology building,	10 83	23 99	44 37	76 04	-	-	-	155 23
Clark hall,	51	88 64	25 46	21 43	-	-	-	136 04
French hall,	61 04	4 30	13 53	1 85	-	-	-	80 72
Wilder hall,	7 71	23 98	12 31	18 47	-	-	-	62 47
Upper plant house,	-	47	8 64	2 32	-	-	-	11 43
Old Durfee range,	-	17 49	5 20	-	-	-	-	22 69
Horticulture barn,	1 12	3 65	-	39 99	-	-	-	44 76
Physics building,	-	3 99	91	16 16	-	-	-	21 06
East experiment station,	-	3 65	17 18	16 49	-	-	-	37 32
West experiment station,	2 23	39 33	6 22	34 33	-	-	-	82 11
East experiment station barn,	-	-	-	4 18	-	-	-	4 18
West experiment station barn,	-	8 62	6 59	65 37	-	-	-	80 58
Rural engineering building,	1 02	2 67	-	103 92	-	-	-	107 61
Microbiology building,	49 28	26 97	58 93	34 07	-	-	-	169 25
Draper hall,	32 29	114 27	28 26	369 24	-	-	$430 68	974 74
Hospital,	1 63	10 87	1 75	11 29	-	-	-	25 54
Stockbridge hall,	17 96	19 35	64 02	367 95	-	-	-	469 28
Cold-storage building,	-	-	-	33 11	-	-	-	33 11
Machine barn,	-	-	1 24	2 02	-	-	-	3 26
Poultry storage building,	51	1 71	-	-	-	-	-	2 22
Poultry demonstration house,	-	1 71	-	31	-	-	-	2 02

EXPENSE OPERATING AND MAINTENANCE — *Concluded.*

	Electric Repairs.	Plumbing Repairs.	Heat Repairs.	C. and M. Repairs.	Janitor.	Bell Ringing.	Sundry.	Totals.
College buildings — *Concluded.*								
Poultry brooding house,	–	–	–	$1 23	–	–	–	$1 23
Poultry killing house,	–	–	$6 78	48	–	–	–	7 26
Piggery,	–	–	–	2 44	–	–	–	2 44
North college,	$51 76	$9 94	11 62	207 93	$572 23	–	$217 00	1,070 48
South college,	60 29	51 62	48 15	165 11	475 05	–	429 80	1,230 02
Chapel,	10 03	2 46	2 62	41 29	139 65	$80 00	–	276 05
College residences: —								
Kellogg place,	–	73	–	8 36	–	–	11 11	20 20
Goldberg place,	–	35	–	4 95	–	–	–	5 30
President's house,	15 30	36 45	14 85	129 75	–	–	43 53	239 88
Waugh house,	1 27	–	–	43 62	–	–	–	44 89
Registrar's house,	4 47	–	–	–	–	–	–	4 47
Farm superintendent's house,	1 05	10 17	24 29	2 05	–	–	–	37 56
Farm help's house,	–	24 00	1 04	2 30	–	–	–	27 34
Stockbridge house,	–	1 66	–	–	–	–	–	1 66
Farm cottage,	–	1 16	15 07	5 54	–	–	–	21 77
Totals,	$406 85	$836 39	$635 19	$2,726 41	$1,377 45	$80 00	$1,132 12	$7,194 41

Summary.

General,	$69,392 68
College buildings,	6,791 34
College residences,	403 07
Total,	$76,587 09

EXPERIMENT STATION.

Disbursements and Receipts.

ACCOUNTS.	Disbursements from Dec. 1, 1916, to Nov. 30, 1917.	Receipts from Dec. 1, 1916, to Nov. 30, 1917.	Apportionment for Year ending Nov. 30, 1917.	Balance to Credit.
Administration,	$1,234 51	$3 48	$1,200 00	—$31 03
Agricultural economics,	368 21	-	750 00	381 79
Agriculture,	8,490 16	4,810 22	3,100 00	—579 94
Apiculture,	51 12	-	120 00	68 88
Botanical,	2,103 43	32 90	2,080 00	9 47
Chemical,	12,970 28	11,939 54	1,000 00	—30 74
Cranberry,	3,528 49	3,172 02	3,000 00	2,643 53
Entomological,	413 18	75	625 00	212 57
Equipment,	197 72	-	750 00	552 28
Feed inspection,	6,772 57	6,000 00	2,048 07[1]	1,275 50
Fertilizer inspection,	9,287 40	9,040 00	859 81[1]	612 41
Freight and express,	256 70	5 51	400 00	148 81
Graves' orchard,	533 64	133 48	700 00	299 84
Horticultural,	1,832 30	7 85	1,800 00	—24 45
Library,	518 51	-	700 00	181 49
Meteorology,	358 22	-	400 00	41 78
Microbiology,	1,704 14	-	1,725 00	20 86
Poultry,	1,907 25	-	2,000 00	92 75
Publications,	735 22	-	1,000 00	264 78
Salaries,	45,271 80	-	47,400 00	2,128 20
Tillson farm,	1,666 66	1,120 55	1,400 00	853 89
Treasurer's office,	336 59	-	350 00	13 41
Veterinary,	1,123 57	560 31	725 00	161 74
Hatch fund,	-	15,000 00	-	-
Adams fund,	-	15,000 00	-	-
State fund,	-	35,000 00	-	-
Totals,	$101,661 67	$101,826 61	$74,132 88	-
Balance beginning fiscal year Dec. 1, 1916.	-	8,523 40	-	-
Balance on hand Nov. 30, 1917,	8,688 34	-	-	-
Totals,	$110,350 01	$110,350 01	-	-

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[1] Balance from previous year.

EXPERIMENT STATION — *Continued.*

Comparative Disbursements and Receipts, 1916–17.

ACCOUNTS.	DISBURSEMENTS.		RECEIPTS.	
	1916.	1917.	1916.	1917.
Administration,	$1,029 25	$1,234 51	$13 46	$3 48
Agricultural economics,	650 24	368 21	–	–
Agriculture,	7,417 23	8,490 16	5,080 69	4,810 22
Apiculture,	102 73	51 12	–	–
Asparagus,	12 26	–	–	–
Botanical,	1,589 04	2,103 43	30 00	32 90
Chemical,	12,069 86	12,970 28	12,002 98	11,939 54
Cranberry,	3,106 97	3,528 49	2,771 12	3,172 02
Entomological,	452 21	413 18	–	75
Equipment,	717 02	197 72	–	–
Feed inspection,	5,632 53	6,772 57	6,000 00	6,000 00
Fertilizer inspection,	11,434 88	9,287 40	9,400 00	9,040 00
Freight and express,	382 33	256 70	91 26	5 51
Graves' orchard,	658 13	533 64	1,131 15	133 48
Horticultural,	1,700 83	1,832 30	53 08	7 85
Library,	682 10	518 51	–	–
Meteorology,	369 11	358 22	–	–
Microbiology,	273 80	1,704 14	–	–
Poultry,	1,811 21	1,907 25	–	–
Publications,	795 14	735 22	–	–
Salaries,	42,986 41	45,271 80	–	–
Tillson farm,	1,921 78	1,666 66	320 96	1,120 55
Treasurer's office,	181 70	336 59	–	–
Veterinary,[1]	977 83	1,123 57	506 00	560 31
Hatch fund,	–	–	15,000 00	15,000 00
Adams fund,	–	–	15,000 00	15,000 00
State fund,	–	–	30,000 00	35,000 00
Totals,	$96,954 59	$101,661 67	$97,400 70	$101,826 61
Balance beginning of fiscal year,	–	–	8,077 29	8,523 40
Balance on hand at close of fiscal year,	8,523 40	8,688 34	–	–
Totals,	$105,477 99	$110,350 01	$105,477 99	$110,350 01

[1] This includes blood test.

EXPERIMENT STATION — *Concluded.*

Analysis of Experiment Station Accounts.

	Adams Fund.	Feed Law.	Fertilizer Law.	Hatch Fund.	State Fund.	Totals.
Salaries,	$14,647 06	$3,890 99	$6,253 32	$15,001 27	$15,623 47	$55,416 11
Labor,	–	277 81	500 85	–	23,900 71	24,679 37
Publications,	–	784 20	872 70	–	690 72	2,347 62
Postage and stationery,	–	73 23	81 33	–	1,462 76	1,617 32
Freight and express,	–	6 57	24 67	–	304 78	336 02
Heat, light, water and power,	–	35 13	131 26	–	397 89	564 28
Chemical and laboratory supplies,	–	235 51	508 09	–	1,525 04	2,268 64
Seeds, plants and sundry supplies,	–	18 70	51 00	–	2,411 71	2,481 41
Fertilizers,	–	–	2 00	–	973 40	975 40
Feed stuffs,	–	–	–	–	1,671 76	1,671 76
Library,	–	–	–	–	522 60	522 60
Tools, machinery and appliances,	–	39 35	–	–	242 99	282 34
Furniture and fixtures,	–	–	–	–	729 74	729 74
Scientific apparatus and specimens,	–	–	11 98	–	555 06	567 04
Live stock,	–	–	–	–	236 72	236 72
Traveling expenses,	–	534 25	845 25	–	3,373 05	4,752 55
Contingent expenses,	–	5 00	–	–	20 00	25 00
Buildings and land,	–	871 83	4 95	–	1,145 47	2,022 25
Equipment,	–	–	–	–	165 50	165 50
Totals,	$14,647 06	$6,772 57	$9,287 40	$15,001 27	$55,953 37	$101,661 67

Summary.

	Disbursements.	Receipts.
Cash on hand Dec. 1, 1916,	–	$8,523 40
Receipts from State Treasurer,	–	41,000 00
Receipts from United States Treasurer,	–	30,000 00
Receipts from other sources,	–	30,826 61
Total disbursements,	$101,661 67	–
	$101,661 67	$110,350 01
Bills receivable Dec. 1, 1916, deducted,	–	2,776 06
Bills payable Dec. 1, 1916, deducted,	865 00	–
	$100,796 67	$107,573 95
Bills receivable Nov. 30, 1917,	–	4,452 97
Bills payable Nov. 30, 1917,	218 78	–
Balance,	11,011 47	–
	$112,026 92	$112,026 92

EXTENSION SERVICE.

Disbursements and Receipts.

CLASSIFICATION.	Disbursements.	Receipts.	Apportionment.	Balance.
Administration,	$1,420 55	$63 41	$1,600 00	$242 86
Director's office,	1,646 89	193 10	1,800 00	346 21
Salaries,	31,467 10	-	33,371 66	1,904 56
Correspondence courses,	1,374 53	661 64	400 00	—312 89
Rural civic planning,	732 73	340 91	700 00	308 18
Local community organization,	782 78	-	700 00	—82 78
Home economics,	702 07	-	500 00	—202 07
Co-operative marketing,	885 24	6 96	800 00	—78 28
County agents' work,	461 69	-	200 00	—261 69
Animal husbandry,	476 41	13 56	400 00	—62 85
Junior extension work,	2,383 06	13 02	1,800 00	—570 04
Dairying,	196 92	-	200 00	3 08
Exhibits,	1,136 78	575 00	500 00	—61 78
Lectures,	165 36	36 00	300 00	170 64
Farm management demonstration,	129 69	46 90	100 00	17 21
Pomology,	487 54	87 49	500 00	99 95
Poultry husbandry,	465 52	179 73	300 00	14 21
Library extension,	165 55	-	200 00	34 45
Printing,	2,868 70	1,535 50	1,300 00	—33 20
War emergency,	6,603 91	38 48	-	—6,565 43
Short courses,	12,194 22	3,538 68	9,680 00	1,024 46
Reserve and emergency,	-	-	6,578 23	-
State Treasurer,	-	50,000 00	-	-
Totals,	$66,747 24	$57,330 38	$61,929 89	-
Balance beginning fiscal year Dec. 1, 1916,	-	12,039 70	-	-
Balance on hand Nov. 30, 1917,	2,622 84	-	-	-
Totals,	$69,370 08	$69,370 08	-	-

Summary.

	Disbursements.	Receipts.
Balance Dec. 1, 1916,[1]	-	$13,634 73
Receipts Nov. 30, 1917,	-	7,330 38
Received from State Treasurer,	-	50,000 00
Received from United States Treasurer,	-	16,594 18
Disbursements to Nov. 30, 1917,[1]	$81,952 97	-
	$81,952 97	$87,559 29
Bills receivable Dec. 1, 1916, deducted,	-	622 12
Bills payable Dec. 1, 1916, deducted,	116 87	-
	$81,836 10	$86,937 17
Bills receivable Nov. 30, 1917,	-	776 12
Bills payable Nov. 30, 1917,	139 72	-
Balance,	5,737 47	-
	$87,713 29	$87,713 29

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[1] Includes Federal Smith-Lever fund.

EXTENSION SERVICE — *Concluded.*

Analysis of Extension Service Disbursements.

	Travel.	Equipment.	Supplies.	Instruction and Lectures.	Salaries.	Miscellaneous.	Labor.	Totals.
Administration,	$1,059 90	-	$235 27	-	-	-	$125 38	$1,420 55
Animal husbandry,	409 73	-	66 68	-	-	-	-	476 41
Agricultural camps,	135 16	-	2,327 84	$1,000 00	-	-	122 60	3,585 60
Beekeeping,	52 69	-	113 43	-	-	-	-	166 12
Conference rural community planning,	141 07	-	115 93	-	-	-	-	257 00
Correspondence courses,	119 09	$2 50	1,168 89	-	-	-	84 05	1,374 53
Co-operative marketing,	816 83	-	68 41	-	-	-	-	885 24
County agents' work,	329 10	-	132 59	-	-	-	-	461 69
County agents' conference,	17 95	-	47 98	-	-	-	-	65 93
Dairying,	143 60	-	53 32	-	-	-	-	196 92
Director's office,	4 92	106 25	1,306 10	-	-	-	229 62	1,646 89
Exhibits,	50 96	-	1,015 83	-	-	-	69 99	1,136 78
Farm management demonstration,	-	25 00	104 69	-	-	-	-	129 69
Farmers' week,	306 60	-	552 34	197 00	-	-	-	1,055 94
Home economics,	336 82	44 50	317 07	-	-	-	3 68	702 07
Junior extension work,	1,450 51	32 25	837 99	-	-	-	62 31	2,383 06
Lectures,	66 37	-	98 99	-	-	-	-	165 36
Library extension,	-	33 53	132 02	-	-	-	-	165 55
Local community organization,	597 45	-	153 96	-	-	-	31 37	782 78
Pomology,	423 16	-	64 38	-	-	-	-	487 54
Poultry convention,	396 35	-	69 17	-	-	-	-	465 52
Poultry husbandry,	122 52	-	158 99	20 00	-	-	-	301 51
Printing,	85 28	-	2,783 42	-	-	-	-	2,868 70
Rural civic planning,	403 51	-	84 88	-	-	-	244 34	732 73
Salaries,	-	-	-	-	$33,554 52	-	-	33,554 52
Summer school,	45 54	-	527 07	2,051 00	-	$352 54	-	2,976 15
Ten weeks' course,	11 64	-	1,038 02	561 25	-	87 64	-	1,698 55
War emergency,	1,990 44	100 79	2,505 20	-	1,304 15	-	703 33	6,603 91
Totals,	$9,517 19	$344 82	$16,080 46	$3,829 25	$34,858 67	$440 18	$1,676 67	$66,747 24

SMITH-LEVER FUND (FEDERAL).

	Disbursements.	Receipts.
Pomology,	$73 02	-
Printing,	421 84	-
Animal husbandry,	62 46	-
Junior extension work,	1,513 26	-
Farm management,	330 91	-
Poultry husbandry,	362 00	-
Home economics,	395 08	-
Dairying,	110 04	-
Extension schools,	489 19	-
Plant diseases,	22 50	-
Sheep husbandry,	62 06	-
Salaries,	10,980 62	-
State leader,	432 75	-
State Treasurer,	-	$16,594 18
Totals,	$15,205 73	$16,594 18
Balance at beginning of fiscal year Dec. 1, 1916,	-	1,595 03
Balance on hand Nov. 30, 1917,	2,983 48	-
	$18,189 21	$18,189 21

SPECIAL APPROPRIATIONS.

	Date made.	Appropriation.	Amount expended to Date.	Unexpended Balance.
Agricultural building,	1914	$210,000 00	$209,074 65	$925 35
Microbiology building,	1915	67,500 00	65,450 31	2,049 69
Improvement and equipment,	1916	20,000 00	20,000 00	-
Agricultural building,	1916	13,732 34	12,243 49	1,488 85
Rural engineering building,	1916	12,000 00	11,997 57	2 43
Market-gardening field station,	1916	8,000 00	7,968 52	31 48
Mount Toby demonstration forest,	1916	30,000 00	30,000 00	-
Improvement and equipment,	1917	33,500 00	15,218 12	18,281 88
Market-garden field station,	1917	10,000 00	6,825 86	3,174 14
Power plant improvements,	1917	40,000 00	7,417 71	32,582 29
Special architect,	1917	358 18	358 18	-
Totals,	-	$445,090 52	$386,554 41	$58,536 11
Amount spent previous to Dec. 1, 1916,	-	-	-	310,822 12
Amount expended during fiscal year,	-	-	-	75,732 29
Unexpended balance Nov. 30, 1917,	-	-	58,536 11	-
	-	$445,090 52	$445,090 52	$445,090 52

INVENTORY — REAL ESTATE.

Land (Estimated Value).

Angus land,	$800 00
Allen place,	500 00
Baker place,	2,500 00
Bangs place,	2,350 00
Brown land,	500 00
Charmbury place,	450 00
Clark place,	4,500 00
College farm,	37,000 00
Cranberry land,	10,975 50
Geo. Cutler, Jr., trustee,	2,700 00
Dickinson land,	7,850 00
Harlow farm,	1,584 63
Hawley and Brown place,	675 00
Kellogg place,	3,368 45
Loomis place,	415 00
Louisa Baker place,	5,000 00
Market-garden field station,	4,800 00
Mount Toby demonstration forest,	30,000 00
Newell farm,	2,800 00
Old creamery place,	1,000 00
Owen farm,	5,000 00
Pelham quarry,	500 00
Westcott place,	2,250 00
Total,	$127,518 58

College Buildings (Estimated Value).

	Inventory at Beginning of Year.	Per Cent.	Value at Beginning of Year less Per Cent. Deterioration.	Repairs and Improvements during Year.	Total Value at Close of Fiscal Year.
Apiary,	$3,042 49	2	$2,981 64	$108 12	$3,089 76
Animal husbandry building,	9,639 33	2	9,446 54	131 70	9,578 24
Chemical laboratory,	8,363 13	5	7,944 97	372 93	8,317 90
Clark hall,	65,671 16	2	64,357 74	136 04	64,493 78
Cold-storage laboratory,	11,617 21	2	11,384 87	33 11	11,417 98
Dairy building,	73,198 22	2	71,734 26	574 45	72,308 71
Dairy barn and storage,	28,722 00	3	27,860 34	409 88	28,270 22
Dining hall,	57,709 05	3	55,977 78	1,018 10	56,995 88
Drill hall and gun shed,	9,383 24	5	8,914 08	252 53	9,166 61
Durfee glass houses, old,	9,122 25	5	8,666 14	315 48	8,981 62
Durfee glass houses, new,	13,847 88	5	13,155 49	–	13,155 49
Entomology building,	77,558 22	2	76,007 06	205 23	76,212 29
Farm bungalow,	2,059 88	3	1,998 08	51 77	2,049 85
Farmhouse,	2,578 19	3	2,500 84	37 56	2,538 40
Farmhouse No. 2,	4,500 00	8	4,140 00	27 34	4,167 34
French hall,	48,839 03	2	47,862 25	80 72	47,942 97
Harlow house,	1,700 00	5	1,615 00	–	1,615 00
Horse barn,	4,858 16	3	4,712 42	28 79	4,741 21
Head of division of horticulture,	2,523 00	5	2,396 85	44 89	2,441 74
Horticultural barn,	2,515 60	3	2,440 13	44 76	2,484 89
Horticultural tool shed,	1,881 80	3	1,825 35	–	1,825 35
Hospital,	15,232 28	2	14,927 63	25 54	14,953 17
Kellogg house,	2,500 00	5	2,375 00	9 09	2,384 09
Machinery barn,	3,779 26	3	3,665 88	3 26	3,669 14
Market-garden field station barn,	–	–	–	–	3,500 00

College Buildings (*Estimated Value*) — Concluded.

	Inventory at Beginning of Year.	Per Cent.	Value at Beginning of Year less Per Cent. Deterioration.	Repairs and Improvements during Year.	Total Value at Close of Fiscal Year.
Mathematical building,	$5,521 88	5	$5,245 79	$206 36	$5,452 15
Microbiology building,	62,144 41	2	60,901 52	169 25	61,070 77
Mount Toby house,	4,000 00	5	3,800 00	-	3,800 00
North dormitory,	24,566 17	2	24,074 85	706 25	24,781 10
Physics laboratory,	5,140 22	5	4,883 21	21 06	4,904 27
Piggery,	2,833 14	3	2,748 15	2 44	2,750 59
Poultry department: —					
No. 1 demonstration building,	1,387 33	2	1,359 58	2 02	1,361 60
No. 2 oil house,	73 50	2	72 03	-	72 03
No. 3 brooder, killing and fattening laboratory,	2,412 18	2	2,363 94	52 49	2,416 43
No. 4 mechanics, storage building and incubator cellar,	3,447 36	2	3,378 41	105 10	3,483 51
No. 5 laying house,	1,728 72	2	1,694 15	-	1,694 15
No. 6 manure shed,	98 00	2	96 04	-	96 04
No. 7 small henhouse,	49 00	2	48 02	-	48 02
No. 8 breeding house,	1,536 64	2	1,505 91	18 00	1,523 91
No. 9 experimental breeding house,	600 00	2	588 00	-	588 00
No. 10 duck house,	98 00	2	96 04	-	96 04
No. 11 unit house for 200 hens,	504 60	2	494 51	8 00	502 51
No. 12 unit house for 100 hens,	400 00	2	392 00	13 00	405 00
Power plant and storage building, including coal pocket,	35,279 72	2	34,574 13	4,022 75	38,596 88
President's house,	11,782 83	3	11,429 35	712 78	12,142 13
Quarantine barn,	517 49	3	501 97	-	501 97
Registrar's house,	1,000 00	5	950 00	4 47	954 47
Rural engineering building,	3,606 06	2	3,533 94	107 61	3,641 55
Sheep barn,	1,432 27	3	1,389 30	30 02	1,419 32
South dormitory,	35,525 35	2	34,814 84	531 45	35,346 29
Stockbridge hall,	181,456 73	2	177,827 60	479 28	178,306 88
Agronomy greenhouse,	2,107 00	2	2,064 86	-	2,064 86
Stockbridge house,	1,500 00	5	1,425 00	1 66	1,426 66
Stone chapel,	29,068 01	2	28,486 65	90 03	28,576 68
Vegetable plant house,	4,392 72	5	4,173 08	11 43	4,184 51
Veterinary laboratory and stable,	23,423 87	2	22,955 39	10 77	22,966 16
Waiting station,	491 78	2	481 94	1 02	482 96
Wilder hall,	36,159 16	2	35,435 98	62 47	35,498 45
Young stock barn,	6,235 54	3	6,048 47	6 69	6,055 16
Totals,	$951,361 06	-	$928,724 99	$11,287 69	$943,512 68

College Equipment (*Estimated Value*).

Administrative division: —	
Dean's office,	$527 60
President's office,	1,691 00
Registrar's office,	1,020 01
Treasurer's office,	2,638 75
Agricultural division: —	
Agronomy,	6,112 93
Animal husbandry,	855 80
Dairy,	17,916 32
Farm administration,	47,241 56
Farm management,	1,091 66
General agriculture,	4,221 86
Poultry,	6,120 47
Rural engineering,	3,207 00
Dining hall,	5,567 68
Extension,	8,274 55

General science: —		
Apiary,		—[1]
Botanical,		$20,511 15
Chemical,		11,450 28
Entomology,		6,189 92
Microbiology,		7,947 06
Mathematics,		2,533 50
Physics,		6,056 82
Veterinary,		10,636 47
Zoölogical and geological,		17,071 53
Graduate school,		76 34
Horticultural division: —		
Floriculture,		29,524 61
Forestry,		2,286 72
General horticulture,		6,934 12
Grounds,		1,648 82
Landscape gardening,		5,019 56
Market gardening,		2,144 40
Pomology,		5,571 77
Hospital,		907 32
Humanities division: —		
Economics and sociology,		160 57
Language and literature,		421 00
Library,		95,943 00
Military,		1,506 07
Operating and maintenance: —		
College supply,		1,877 16
Fire apparatus,		1,851 15
General maintenance,		123,609 36
Equipment,	$105,631 29	
Carpentry and masonry supplies,	6,398 20	
Electrical supplies,	2,581 06	
Heating and plumbing supplies,	7,687 52	
Painting supplies,	1,311 29	
Janitor's supplies,		939 29
Sewer line,		12,137 79
Water mains,		10,584 31
Physical education,		2,196 75
Rural social science: —		
Agricultural economics,		694 65
Agricultural education,		622 15
Rural sociology,		248 81
Textbooks,		1,733 59
Trophy room,		1,564 74
Total,		$499,087 97

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[1] Not received on time.

Experiment Station Buildings (Estimated Value).

	Inventory at Beginning of Year.	Per Cent.	Cost at Beginning of Year less Per Cent. Deterioration.	Repairs and Improvements during Year.	Total Value at Close of Year.
Agricultural laboratory,	$14,966 50	2	$14,667 17	$37 32	$14,704 49
Agricultural barns,	4,777 47	3	4,634 15	50 50	4,684 65
Agricultural farmhouse,	1,412 47	3	1,370 10	5 30	1,375 40
Agricultural glass house,	451 25	5	428 69	-	428 69
Cranberry buildings,	2,490 00	5	2,365 50	-	2,365 50
Plant and animal chemistry laboratory,	29,160 71	2	28,577 50	82 11	28,659 61
Plant and animal chemistry barns,	3,920 98	3	3,803 35	161 64	3,964 99
Plant and animal chemistry dairy,	1,881 80	3	1,825 35	-	1,825 35
Six poultry houses,	576 24	2	564 72	21 00	585 72
Entomological glass houses,	744 56	5	707 33	75 00	782 33
Totals,	$60,381 98	-	$58,943 86	$432 87	$59,376 73

Experiment Station Equipment (Estimated Value).

Agricultural economics department,	$57 14
Agricultural laboratory,	7,310 93
Botanical laboratory,	5,471 09
Chemical laboratory,	22,161 01
Cranberry station,	16,314 52
Director's office,	5,696 64
Entomological laboratory,	23,550 24
Horticultural laboratory,	4,707 63
Meteorology laboratory,	855 00
Microbiology laboratory,	1,479 55
Poultry department,	4,517 78
Treasurer's office,	1,130 25
Tillson farm,	451 75
Graves' orchard,	45 00
Total,	$93,748 53

Inventory Summary.

Land,	$122,718 58
College buildings,	940,012 68
College equipment,	499,087 97
Experiment station buildings,	59,376 73
Experiment station equipment,	93,748 53
Total,	$1,714,944 49

	Acres.
College estate, area,	567.79
Cranberry station, Wareham, area,	23.67
Market-garden field station, Lexington, area,	12.00
Mount Toby demonstration forest, area,	755.27
Rifle range,	46.2
Pelham quarry,	.5
Total acreage,	1,405.43

STUDENT'S TRUST FUND ACCOUNT.

	Disbursements, Year ending Nov. 30, 1917.	Receipts, Year ending Nov. 30, 1917.	Balance on Hand.	Balance brought forward Dec. 1, 1916.
Athletics,	$5,928 80	$6,415 72	$2,291 43	$1,804 51
Dining hall,	52,349 19	47,140 28	—17,214 10	—12,005 19
Keys,	56 50	54 50	33 75	35 75
Student deposits,	16,298 18	18,569 49	10,328 55	8,057 24
Social union,	947 48	962 94	949 86	934 40
Textbooks,	5,443 08	5,039 27	778 06	1,181 87
Athletic field,	1,675 98	1,554 99	—373 21	—252 22
Uniforms,	2,710 15	2,215 15	1,928 64	2,423 64
Totals,	$85,409 36	$81,952 34	—$1,277 02	$2,180 00
Balance on hand Dec. 1, 1916,	-	2,180 00	-	-
Balance on hand Nov. 30, 1917,	—1,277 02	-	-	-
	$84,132 34	$84,132 34	-	-

CONDENSED OPERATING STATEMENT OF THE DINING HALL.

		Operating charges.	Income.
1916.			
Dec. 1.	Balance,	$12,005 19	
1917.			
Nov. 30.	Total disbursements,	52,349 19	
	Outstanding bills,	2,116 27	
	Total collections,		$47,140 28
	Accounts outstanding,		432 46
	Inventory,		4,798 75
	Balance,		14,099 16
		$66,470 65	$66,470 65

ENDOWMENT FUND.[1]

	Principal.	Income.
United States grant (5 per cent.),	$219,000 00	$7,300 00
Commonwealth grant (3½ per cent.),	142,000 00	3,313 32
	-	$10,613 32

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[1] This fund is in the hands of the State Treasurer, and the Massachusetts Agricultural College receives two-thirds of the income from the same.

BURNHAM EMERGENCY FUND.

	Market Value Dec. 1, 1917.	Par Value.	Income.
Two bonds American Telephone and Telegraph Company 4s, at $830,	$1,660 00	$2,000 00	$80 00
Two bonds Western Electric Company 5s, at $971,	1,942 00	2,000 00	100 00
	$3,602 00	$4,000 00	$180 00
Unexpended balance Dec. 1, 1916,	–	–	500 55
Cash on hand Nov. 30, 1917,	–	–	$680 55

LIBRARY FUND.

Five bonds New York Central & Hudson River Railroad Company 4s, at $768.75,	$3,843 75	$5,000 00	$200 00
Five bonds Lake Shore & Michigan Southern Railroad Company 4s, at $850,	4,250 00	5,000 00	200 00
Two shares New York Central & Hudson River Railroad Company stock, at $680,	1,360 00	200 00	10 00
Amherst Savings Bank, deposit,	167 77	167 77	7 09
	$9,621 52	$10,367 77	$417 09
Nov. 20, 1917, transferred to college library account,	–	–	417 09

SPECIAL FUNDS.

Endowed Labor Fund (the Gift of a Friend of the College).

Two bonds American Telephone and Telegraph Company 4s, at $830,	$1,660 00	$2,000 00	$80 00
Two bonds Lake Shore & Michigan Southern Railroad Company 4s, at $850,	1,700 00	2,000 00	80 00
One bond New York Central Railroad debenture 4s,	786 33	1,000 00	40 00
Amherst Savings Bank, deposit,	143 39	143 39	6 07
One bond Kansas City Street Railway 5½s,	980 00	1,000 00	55 00
	$5,269 72	$6,143 39	$261 07
Unexpended balance Dec. 1, 1916,	–	–	537 04
Cash on hand Nov. 30, 1917,	–	–	$798 11

Whiting Street Scholarship Fund.

One bond New York Central debenture 4s,	$786 33	$1,000 00	$40 00
Amherst Savings Bank, deposit,	271 64	271 64	11 51
	$1,057 97	$1,271 64	$51 51
Unexpended balance Dec. 1, 1916,	–	–	239 18
Cash on hand Nov. 30, 1917,	–	–	$290 69

Special Funds — *Continued.*

Hills Fund.

	Market Value Dec. 1, 1917.	Par Value.	Income.
One bond American Telephone and Telegraph Company 4s, at	$830 00	$1,000 00	$40 00
One bond New York Central & Hudson River Railroad debenture 4s, at	786 33	1,000 00	40 00
One bond New York Central Railroad debenture 4s, .	786 33	1,000 00	40 00
Three bonds Pacific Telephone and Telegraph Company 5s, at $920, ...	2,760 00	3,000 00	150 00
One bond Western Electric Company 5s, at . . .	971 00	1,000 00	50 00
Boston & Albany Railroad stocks, 3⅝ shares, at $126, .	456 75	362 50	31 68
Amherst Savings Bank, deposit, ...	72 75	72 75	3 06
Electric Securities Company bonds, 1⁹⁄₅₀ shares, at $965,	1,138 70	1,180 00	59 00
Kansas City Street Railway 5½, ...	980 00	2,000 00	110 00
	$8,781 86	$10,615 25	$523 74
Unexpended balance Dec. 1, 1916, ...	–	–	1,380 41
	–	–	$1,904 15
Disbursements for fiscal year ending Nov. 30, 1917, .	–	–	1,013 00
Cash on hand Nov. 30, 1917, ...	–	–	$891 15

Mary Robinson Fund.

Amherst Savings Bank, deposit, ...	$142 00	$142 00	$6 03
Boston & Albany Railroad stock, ⅜ share, at $126, . .	47 25	38 00	3 32
Electric Securities Company bonds, ⁴¹⁄₅₀ share, at $965, .	791 30	820 00	41 00
	$980 55	$1,000 00	$50 35
Unexpended balance Dec. 1, 1916, ...	–	–	138 68
Cash on hand Nov. 30, 1917, ...	–	–	$189 03

Grinnell Prize Fund.

Ten shares New York Central & Hudson River Railroad stock, at $69, ...	$690 00	$1,000 00	$50 00
Unexpended balance Dec. 1, 1916, ...	–	–	195 74
	$690 00	$1,000 00	$245 74
Disbursements for prizes, ...	–	–	–
Cash on hand Nov. 30, 1917, ...	–	–	$245 74

Gassett Scholarship Fund.

One bond New York Central & Hudson River Railroad debenture 4s, ...	$786 33	$1,000 00	$40 00
Amherst Savings Bank, deposit, ...	11 64	11 64	46
	$797 97	$1,011 64	$40 46
Unexpended balance Dec. 1, 1916, ...	–	–	182 77
Cash on hand Nov. 30, 1917, ...	–	–	$223 23

SPECIAL FUNDS — *Concluded.*

Massachusetts Agricultural College (Investment).

	Market Value Dec. 1, 1917.	Par Value.	Income.
One share New York Central & Hudson River Railroad stock,	$69 00	$100 00	$5 00
Unexpended balance Dec. 1, 1916,	–	–	80 45
Cash on hand Nov. 30, 1917,	–	–	$85 45

Danforth Keyes Bangs Fund.

		Market Value Dec. 1, 1917.	Par Value.	Income.
Two bonds Pacific Telephone and Telegraph Company 5s, at $920,		$1,840 00	$2,000 00	$100 00
Two bonds Union Electric Light and Power Company 5s, at $930,		1,860 00	2,000 00	100 00
Two bonds American Telephone and Telegraph Company 4s, at $830,		1,660 00	2,000 00	80 00
Interest from student loans,		–	–	44 88
		$5,360 00	$6,000 00	$324 88
Unexpended balance Dec. 1, 1916,		–	–	1,000 25
		–	–	$1,325 13
Total loans made to students during fiscal year,	$1,794 00			
Cash received on account of student loans,	1,669 00			
Excess of loans made over accounts paid by students,		–	–	125 00
Cash on hand Nov. 30, 1917,		–	–	$1,200 13

John C. Cutter Fund.

	Market Value Dec. 1, 1917.	Par Value.	Income.
One bond Pacific Telephone and Telegraph Company 5s,	$920 00	$1,000 00	$50 00
Unexpended balance Dec. 1, 1916,	–	–	68 17
	$920 00	$1,000 00	$118 17
Disbursements for fiscal year to date,	–	–	22 64
Cash on hand Nov. 30, 1917,	–	–	$95 53

William R. Sessions Fund.

	Market Value Dec. 1, 1917.	Par Value.	Income.
One bond New York Central & Hudson River Railroad stock 6s,	$465 00	$500 00	$30 00
Amherst Savings Bank, deposit,	4,500 00	4,500 00	191 25
	$4,965 00	$5,000 00	$221 25
Disbursements for fiscal year to date,	–	–	46 10
	–	–	$175 15
Cash on hand Nov. 30, 1916,	–	–	100 56
Cash on hand Nov. 30, 1917,	–	–	$275 71

Alvord Dairy Scholarship Fund.

		Market Value Dec. 1, 1917.	Par Value.	Income.
Amherst Savings Bank, deposit,		$4,000 00	$4,000 00	$170 00
Overdraft Dec. 1, 1916,	$430 00	–	–	–
Less amount of receipts,	170 00	–	–	–
Overdraft Nov. 30, 1917,		–	–	$260 00

Summary of Balances on Hand of the Income from Funds held in Trust by the Massachusetts Agricultural College.

Burnham emergency fund,		$680 55
Endowed labor fund,		798 11
Whiting Street scholarship fund,		290 69
Hills fund,		891 15
Mary Robinson fund,		189 03
Grinnell prize fund,		245 74
Gassett scholarship fund,		223 23
Massachusetts Agricultural College investment fund,		85 45
Danforth Keyes Bangs fund,		1,200 13
John C. Cutter fund,		95 53
William R. Sessions fund,		275 71
		$4,975 32
Alvord dairy scholarship fund overdraft,		260 00
		$4,715 32
Angus land,	$800 00	
Liberty Loan,	800 00	
		1,600 00
		$3,115 32

I hereby certify that I have this day examined the Massachusetts Agricultural College account, as reported by the Treasurer, Fred C. Kenney, for the year ending Nov. 30, 1917. All bonds and investments are as represented in the treasurer's report. All disbursements are properly vouched for, and all cash balances are found to be correct.

CHARLES A. GLEASON,
Auditor.

Dec. 19, 1917.

History of Special Funds.

Burnham emergency fund: —

A bequest of $5,000 from T. O. H. P. Burnham of Boston, made without any conditions. The trustees of the college directed that $1,000 of this fund should be used in the purchase of the Newell land and Goessmann library. The fund now shows an investment of $4,000 00

Library fund: —

The library of the college at the present time contains 56,090 volumes. The income from the fund raised by the alumni and others is devoted to its increase, and additions are made from time to time as the needs of the different departments require. Dec. 27, 1883, William Knowlton gave $2,000; Jan. 1, 1894, Charles L. Flint gave $1,000; in 1887, Elizur Smith of Lee, Mass., gave $1,315. These were the largest bequests, and now amount to . . . 10,000 00

Endowed labor fund: —	
Gift of a friend of the college in 1901, income of which is to be used for the assistance of needy and deserving students, ...	$5,000 00
Whiting Street scholarship fund: —	
Gift of Whiting Street of Northampton, for no special purpose, but to be invested and the income used. This fund is now used exclusively for scholarship, ...	1,000 00
Hills fund: —	
Gift of Leonard M. and Henry F. Hills of Amherst, Mass., in 1867, to establish and maintain a botanic garden, .	10,000 00
Mary Robinson fund: —	
Gift of Miss Mary Robinson of Medfield, in 1874, for scholarship, ...	1,000 00
Grinnell prize fund: —	
Gift of Hon. Wm. Claflin, to be known as the Grinnell agricultural prize, to be given to the two members of the graduating class who may pass the best oral and written examination in theory and practice of agriculture, given in honor of George B. Grinnell of New York, . . .	1,000 00
Gassett scholarship fund: —	
Gift of Henry Gassett of Boston, the income to be used for scholarship, ...	1,000 00
Massachusetts Agricultural College investment fund: —	
Investment made by vote of trustees in 1893 to purchase one share of New York Central & Hudson River Railroad stock. The income from this fund has been allowed to accumulate, ...	100 00
Danforth Keyes Bangs fund: —	
Gift of Louisa A. Baker of Amherst, Mass., April 14, 1909, the income thereof to be used annually in aiding poor, industrious and deserving students to obtain an education in said college, ...	6,000 00
John C. Cutter fund: —	
Gift of Dr. John C. Cutter of Worcester, Mass., an alumnus of the college, who died in August, 1909, to be invested by the trustees, and the income to be annually used for the purchase of books on hygiene, ...	1,000 00
Alvord dairy scholarship fund: —	
Gift of Henry E. Alvord, who was the first instructor in military tactics, 1869–71, and a professor of agriculture, 1885–87, at this institution. The income of this fund is to be applied to the support of any worthy student of said college, graduate or post-graduate, who may be making a specialty of the study of dairy husbandry (broadly considered), with the intention of becoming an investigator,	

teacher or special practitioner in connection with the dairy industry, provided that no benefits arising from such fund shall at any time be applied to any person who then uses tobacco in any form or fermented or spirituous beverages, or is known to have done so within one year next preceding, ...	$4,000 00
William R. Sessions fund: —	
In accordance with the request of my deceased wife, Clara Markham Sessions, made in her last will, I bequeath to the trustees of the Massachusetts Agricultural College, Amherst, Mass., the sum of $5,000, it being the amount received by me from the estate of the said Clara Markham Sessions. The said $5,000 to be kept by the said trustees a perpetual fund, the income from which shall be for the use of the Massachusetts Agricultural College; and according to the further request of my deceased wife, made in her last will, this is to be known as the William R. Sessions fund, and is to be a memorial of William R. Sessions; and it is my special request that the said trustees shall make record of the fact that this fund came from the estate of my deceased wife, Clara Markham Sessions, in accordance with her request made in her last will, . .	5,000 00
	$49,100 00

FRED C. KENNEY,
Treasurer.

THE M. A. C. BULLETIN
AMHERST, MASS.

Vol. X. No. 1. January, 1918

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CATALOGUE

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

1917-1918.

FIFTY-FIFTH ANNUAL REPORT.
PART II.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
32 DERNE STREET.
1918.

> Without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and mechanic arts, in such manner as the legislatures of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life. — *Act of Congress, July 2, 1862.*

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST.

CATALOGUE, 1917-1918.

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32 DERNE STREET.
1918.

Publication of this Document
approved by the
Supervisor of Administration.

The Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Dec. 1, 1917.

To His Excellency SAMUEL W. McCALL.

SIR: — On behalf of the trustees of the Massachusetts Agricultural College I have the honor to transmit herewith, to Your Excellency and the Honorable Council, Part II. of the fifty-fifth annual report of the trustees, this being the catalogue of the college.

I am, very respectfully, your obedient servant,

KENYON L. BUTTERFIELD,
President.

THE MASSACHUSETTS AGRICULTURAL COLLEGE.

This issue of the catalogue represents the status of the college for the current college year, with provisional announcement of courses of study and other matters for the year to follow. When deemed necessary, additional announcements are made in a supplementary bulletin, published in the spring.

The college reserves, for itself and its departments, the right to withdraw or change the announcements made in its catalogue. Special publication will be made should it become necessary on account of important changes.

CALENDAR.

1917-18-19.

REGULAR COURSES.

1917.

October 10, Wednesday, 1.30 P.M.,	Fall term begins; chapel.
November 28, Wednesday, 12.30 P.M.–Friday, November 30, 1.30 P.M.,	Thanksgiving recess.
December 15, Saturday, 12.30 P.M.,	Fall term ends.
December 17, Monday, 7.30 A.M.,	Winter term begins.
December 22, Saturday, 12.30 P.M.,	Christmas recess begins.
December 31, Monday, 1.30 P.M.,	Christmas recess ends.

1918.

February 23, Saturday, 12.30 P.M.,	Winter term ends.
February 25, Monday, 7.30 A.M.,	Spring term begins.
April 26, Friday, 5.30 P.M.,	Spring term ends.
April 26, 27, Friday, Saturday,	Commencement.
June 27–29, Thursday–Saturday,	Entrance examinations.
September 18–21, Wednesday–Saturday,	Entrance examinations.
September 25,[1] Wednesday, 1.30 P.M.,	Fall term begins; chapel.
November 27, Wednesday, 12.30 P.M.–Friday, November 29, 1.30 P.M.,	Thanksgiving recess.
December 20, Friday, 5.30 P.M.,	Fall term closes.
December 30, Monday, 1.30 P.M.,	Winter term begins.

1919.

March 21, Friday, 5.30 P.M.,	Winter term ends.
March 31, Monday, 1.30 P.M.,	Spring term begins.
May 30, Friday,	Holiday—Memorial Day.
June 21–25, Saturday–Wednesday,	Commencement.
June 25, Wednesday,	Spring term closes.
June 26–28, Thursday–Saturday,	Entrance examinations.
September 17–20, Wednesday–Saturday,	Entrance examinations.
September 24, Wednesday, 1.30 P.M.,	Fall term begins; chapel.

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[1] This is the calendar for a normal year; if any modification in the length of terms is made such will be announced in the autumn. The date of opening in 1918 will be as stated above.

MASSACHUSETTS AGRICULTURAL COLLEGE.

HISTORY. — The Massachusetts Agricultural College was among the first of those organized under the national land grant act of 1862. This act granted public lands to the several States and Territories, the funds realized from the sale of which should be used to establish colleges of agriculture and mechanic arts; the bill was framed by the late Senator Justin Smith Morrill of Vermont. The Legislature of Massachusetts has granted money for the erection of nearly all the buildings now on the grounds, and makes annual appropriations for the maintenance of the college.

The college was incorporated in 1863, and on the 2d of October, 1867, was formally opened to its first class of students. At that time four buildings had been erected, and there were four regular instructors employed by the institution. In 1882 the State located its agricultural experiment station on the grounds of the college. Later, after the Federal law was passed granting financial aid to experiment stations, the Massachusetts Agricultural Experiment Station was consolidated with the Federal station, and subsequently the whole was incorporated with the college.

COURSES. — The college offers an education without tuition fee to any student who is a resident of Massachusetts and who meets the requirements for admission. Women are admitted on the same basis as are men. Students who are not residents of Massachusetts are required to pay a nominal tuition fee. The four-year[1] course leads to the degree of bachelor of science, and the graduate school offers advanced courses leading to the degrees of master of science, doctor of philosophy and master of agriculture. The winter school of ten weeks, for admission to which no scholastic requirements are made, is held each winter, beginning early in January. There are other short courses at the college, such as the beekeepers' course and summer school. Various forms of extension teaching are carried on away from the college, such as correspondence courses, traveling schools, educational exhibits, lecture courses, demonstrations and circulating libraries.

PURPOSE OF THE COLLEGE. — The chief purpose of the college is to prepare men and women for the agricultural vocations. In this statement the term "agricultural vocations" is used in its broadest sense. Courses are offered which give efficient training in various agricultural pursuits, such as general farming, dairying, management of estates, poultry husbandry, fruit growing, market gardening, landscape gardening and forestry. Students are also fitted for positions in institutions designed for investigation in many sciences underlying the great agricultural industry, for teaching in agricultural colleges and high schools, for scientific experts in chemistry, entomology, botany and microbiology and for business operations having connection with practical agriculture.

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[1] Twenty-seven teaching departments offer instruction in agriculture, horticulture, sciences, the humanities and rural social science. A system of major courses permits a student to elect major work in 1 of 17 departments, specializing in that and allied subjects for a period of two years.

Though the agricultural vocations are thus the chief concern of the college, students also find the course one that fits them admirably for pursuits in which the sciences, particularly chemistry, botany and zoölogy, are an essential preparation. Still other students find the course a desirable education without regard to future occupation. The course of study is designed to give a student a general college education, and in addition to make it possible for him to specialize in any department in which a major course is offered.

Location and Equipment. — The agricultural college is located in the town of Amherst. The grounds comprise more than 600 acres, lying about a mile north of the village center. In addition the college has a demonstration forest of 755 acres, located some 8 miles north of the campus. The equipment of the college, both in buildings and facilities for instruction, is excellent. Amherst is about 98 miles from Boston, and may be reached over the Central Massachusetts division of the Boston & Maine Railroad, or by way of the Central Vermont Railroad. Electric car lines connect Amherst with Northampton, Holyoke and Springfield.

THE MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

Massachusetts provided for the establishment of an agricultural experiment station in 1882. This station, though on the college grounds and supported by the State, was then without organic connection with the college. Under an act of Congress, passed in 1887, an agricultural experiment station was established as a department of the college, and was supported by the general government. For a time, therefore, Massachusetts had two experiment stations at the college. In 1894 these were combined, and the station reorganized as a department of the college. It is now supported by funds from both the State and the general government. In 1906 the general government largely increased its support of experiment stations, on condition, however, that the money thus provided should be used only for research. The station now receives about one-half of its support from the State.

The station is under the direct supervision of the Board of Trustees. The chief officer is the director, who is responsible to the president and to a committee of the Board. The station is organized into a number of departments, all co-operating toward the betterment of agriculture. In most cases the heads of the station departments are heads of corresponding departments in the college. The work of the station takes three directions; namely, control work, experimentation and investigation. The station publishes numerous bulletins and two annual reports, one scientific, the other for practical farmers and for general distribution. These publications, conveying information as to results of experiments, are free, and circulate extensively, the mailing list containing some 20,000 addresses.

The Corporation.

ORGANIZATION OF 1918.

Members of the Corporation.

	TERM EXPIRES
Davis R. Dewey of Cambridge,	1919
John F. Gannon of Worcester,	1919
Arthur G. Pollard of Lowell,	1920
George H. Ellis of West Newton,	1920
Elmer D. Howe of Marlborough,	1921
Edmund Mortimer of Grafton,	1921
Nathaniel I. Bowditch of Framingham,	1922
William Wheeler of Concord,	1922
Charles A. Gleason of New Braintree,	1923
James F. Bacon of Boston,	1923
Frank Gerrett of Greenfield,	1924
Harold L. Frost of Arlington,	1924
Charles H. Preston of Danvers,	1925
Frank A. Hosmer of Amherst,	1925

Members Ex Officio.

His Excellency Governor Samuel W. McCall, *President of the Corporation.*
Kenyon L. Butterfield, *President of the College.*
Payson Smith, *State Commissioner of Education.*
Wilfrid Wheeler, *Secretary of the State Board of Agriculture.*

Officers of the Corporation.

His Excellency Governor Samuel W. McCall of Boston, *President.*
Charles A. Gleason of New Braintree, *Vice-President.*
Wilfrid Wheeler of Concord, *Secretary.*
Fred C. Kenney of Amherst, *Treasurer.*
Charles A. Gleason of New Braintree, *Auditor.*

Standing Committees of the Corporation.[1]

Committee on Finance.

Charles A. Gleason, *Chairman.*
George H. Ellis.
Nathaniel I. Bowditch.
Arthur G. Pollard.
Frank A. Hosmer.
Edmund Mortimer.

Committee on Course of Study and Faculty.

William Wheeler, *Chairman.*
Frank A. Hosmer.
Elmer D. Howe.
Payson Smith.
Davis R. Dewey.
John F. Gannon.
James F. Bacon.

Committee on Farm.

Nathaniel I. Bowditch, *Chairman.*
Frank Gerrett.
George H. Ellis.
Edmund Mortimer.

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[1] The president of the college is ex-officio member of each standing committee.

Committee on Horticulture.

Harold L. Frost, *Chairman.*
Elmer D. Howe.
Charles A. Gleason.
Wilfrid Wheeler.
Edmund Mortimer.

Committee on Experiment Department.[1]

Charles H. Preston, *Chairman.*
Arthur G. Pollard.
Wilfrid Wheeler.
Harold L. Frost.
Edmund Mortimer.

Committee on Buildings and Arrangement of Grounds.

Frank Gerrett, *Chairman.*
Charles H. Preston.
William Wheeler.
George H. Ellis.
James F. Bacon.

Committee on Extension Service.

Elmer D. Howe, *Chairman.*
Davis R. Dewey.
George H. Ellis.
Nathaniel I. Bowditch.
Harold L. Frost.
John F. Gannon.

Examining Committee of Overseers from the State Board of Agriculture.

John Bursley of West Barnstable.
Frank P. Newkirk of Easthampton.
William E. Patrick of Warren.
L. L. Richardson of Leominster.
Howard A. Parsons of Amherst.

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[1] The director of the experiment station is a member of the committee on experiment department, without vote.

OFFICERS OF THE INSTITUTION.

[The names of the faculty are arranged in groups according to rank. Within these groups the order depends upon seniority of service in the college, not upon seniority of appointment to the position now held. Changes in personnel occurring after Nov. 30, 1917, are not indicated.]

THE FACULTY.

Kenyon L. Butterfield, A.M., L.L.D., President of the College and Head of Division of Rural Social Science.	President's House.
Charles H. Fernald, Ph.D., Honorary Director of the Graduate School.	3 Hallock Street.
Edward M. Lewis, A.M., Dean of the College and Professor of Languages and Literature.	19 Lincoln Avenue.
Fred C. Kenney, Treasurer of the College.	Mount Pleasant.
William P. Brooks, Ph.D., Director of the Experiment Station and Lecturer on Soil Fertility.	6 Farview Way.
William D. Hurd,[1] M.Agr., Director of the Extension Service and Supervisor of Short Courses.	46 Amity Street.
Charles E. Marshall, Ph.D., Director of the Graduate School and Professor of Microbiology.	44 Sunset Avenue.
Frank A. Waugh, M.Sc., Head of Division of Horticulture and Professor of Landscape Gardening.	Campus.
James A. Foord,[2] M.Sc.Agr., Head of Division of Agriculture and Professor of Farm Management.	54 Lincoln Avenue.
Robert J. Sprague, Ph.D., Head of Division of Humanities and Professor of Economics and Sociology.	Mount Pleasant.
Joseph B. Lindsey, Ph.D., Goessmann Professor of Chemistry.	47 Lincoln Avenue.
Charles Wellington, Ph.D., Professor of Chemistry.	34 Amity Street.
James B. Paige, B.Sc., D.V.S., Professor of Veterinary Science.	42 Lincoln Avenue.
Philip B. Hasbrouck, B.Sc., Registrar of the College and Professor of Physics.	Fearing Street.
John E. Ostrander, A.M., C.E., Professor of Mathematics and Civil Engineering.	33 North Prospect Street.
Henry T. Fernald, Ph.D., Professor of Entomology, Chairman of Division of Science.	44 Amity Street.
A. Vincent Osmun, M.Sc., Professor of Botany.	16 Northampton Road.
Clarence E. Gordon, Ph.D., Professor of Zoölogy and Geology.	38 Lincoln Avenue.
William R. Hart, A.M., L.L.B., Professor of Agricultural Education.	97 Pleasant Street.
Fred C. Sears, M.Sc., Professor of Pomology.	Mount Pleasant.
William P. B. Lockwood, M.Sc., Professor of Dairying.	34 North Prospect Street.

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[1] On leave of absence, service with United States Department of Agriculture.

[2] On leave of absence to Jan. 15, 1918.

Alexander E. Cance, Ph.D., Professor of Agricultural Economics.	9 Fearing Street.
Joseph S. Chamberlain, Ph.D., Professor of Organic and Agricultural Chemistry.	Mount Pleasant.
John C. Graham, B.Sc.Agr., Professor of Poultry Husbandry.	Lincoln Avenue.
G. Chester Crampton, Ph.D., Professor of Insect Morphology.	The Davenport.
Charles A. Peters, Ph.D., Professor of Inorganic and Soil Chemistry.	2 Sunset Avenue.
Curry S. Hicks, B.Pd., Professor of Physical Education and Hygiene.	The Davenport.
William D. Clark,[1] A.B., M.F., Professor of Forestry.	– –
Ernest Anderson,[2] Ph.D., Professor of General and Physical Chemistry.	– –
Christian I. Gunness, B.Sc., Professor of Rural Engineering.	105 Butterfield Terrace.
Harold F. Tompson, B.Sc., Professor of Market Gardening.	10 Temple Street, Arlington.
John Phelan, A.M., Professor of Rural Sociology.	29 Northampton Road.
John C. McNutt, B.Sc.Agr., Professor of Animal Husbandry.	33 East Pleasant Street.
Richard H. Wilson, Colonel, U.S.A., Professor of Military Science and Tactics.	The Perry.
Robert W. Neal, A.M., Associate Professor of English.	Kendrick Place.
Edgar L. Ashley, A.M., Associate Professor of German.	24 Pleasant Street.
Alexander A. Mackimmie, A.M., Associate Professor of French.	Pine Street, North Amherst.
Burton N. Gates, Ph.D., Associate Professor of Beekeeping.	42 Lincoln Avenue.
George E. Gage, Ph.D., Associate Professor of Animal Pathology.	27 Sunset Avenue.
Walter W. Chenoweth, A.B., M.Sc., Associate Professor of Pomology.	North Amherst.
Harold E. Robbins, B.Sc., A.M., Associate Professor of Physics.	4 Nutting Avenue.
Paul J. Anderson, Ph.D., Associate Professor of Botany.	McClure Street.
Arthur B. Beaumont, B.Sc., Associate Professor of Agronomy.	103 Butterfield Terrace.
Ralph J. Watts, B.Sc., Secretary of the College.	101 Butterfield Terrace.
Charles R. Green, B.Agr., Librarian of the College.	Mount Pleasant.
C. Robert Duncan, B.Sc., C.E., Assistant Professor of Mathematics.	23 Lincoln Avenue.
Arthur K. Harrison, Assistant Professor of Landscape Gardening.	6 Allen Street.
William L. Machmer,[3] A.M., M.E., Assistant Professor of Mathematics.	3 Kendrick Place.
Walter E. Prince, Ph.B., A.M., Assistant Professor of English.	4 Kendrick Place.
Harold M. Gore,[4] B.Sc., Assistant Professor of Physical Education.	– –

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[1] On leave of absence, service with New England Fuel Administrator.

[2] On leave of absence.

[3] On leave of absence, service with United States Department of Agriculture.

[4] On leave of absence, war service.

Orton L. Clark, B.Sc., ... 16 College Street.
Assistant Professor of Botany.

Loyal F. Payne, B.Sc., ... 12 Chestnut Street.
Assistant Professor of Poultry Husbandry.

Lorian P. Jefferson, A.M., ... 84 Pleasant Street.
Assistant Professor in the Division of Rural Social Science.

Earl Jones, M.Sc.Agr., ... 8 Allen Street.
Assistant Professor of Agronomy.

Charles H. Thompson, M.Sc., ... Mount Pleasant.
Assistant Professor of Horticulture.

Andrew S. Thomson, Ph.B., A.M., ... 10½ Kellogg Avenue.
Assistant Professor of Market Gardening, and in charge of Short Courses.

Orville A. Jamison, M.Sc., ... 7 East Pleasant Street.
Assistant Professor of Dairying.

Arao Itano, Ph.D., ... 7 East Pleasant Street.
Assistant Professor of Microbiology.

John T. Wheeler,[1] B.Sc.Agr., ... – –
Assistant Professor of Horticulture.

Charles H. Patterson, A.B., A.M., ... 26 Lincoln Avenue.
Assistant Professor of English.

August G. Hecht, B.Sc., ... 3 Mount Pleasant.
Assistant Professor of Floriculture.

Byron E. Pontius, B.Sc.Agr., ... 5½ East Pleasant Street.
Assistant Professor of Animal Husbandry.

Frank W. Rane, M.F., ... Boston.
Lecturer in Forestry.

Helena T. Goessmann, M.Ph., ... 13 Main Street.
Instructor in English.

—— —— . . . . – –
Instructor in French.

Arthur N. Julian, A.B., ... 4 Farview Way.
Instructor in German.

Frederick A. McLaughlin, B.Sc., ... 15 Fearing Street.
Instructor in Botany.

Paul Serex, Jr., M.Sc., ... 5 East Pleasant Street.
Instructor in Chemistry.

Frederick G. Merkle, M.Sc., ... East Street.
Instructor in Agronomy.

Stanley E. VanHorn, ... 20 Amity Street.
Instructor in Dairying.

Burt A. Hazeltine,[2] B.Sc., ... – –
Instructor in Mathematics.

William S. Regan, Ph.D., ... The Davenport.
Instructor in Entomology.

Frank P. Rand, A.M., ... North Amherst.
Instructor in English.

Walter M. Peacock, M.Sc.Agr., ... 24 Pleasant Street.
Instructor in Farm Management.

—— ——, ... – –
Instructor in Botany,

Harry D. Drain, B.Sc.Agr., ... 24 Pleasant Street.
Instructor in Dairying.

Stanley C. Ball, Ph.D., ... 45 Amity Street.
Instructor in Zoölogy.

Egerton G. Hood, B.Sc.Agr., ... 15 Spring Street.
Instructor in Microbiology.

Otto F. Wilkinson, B.Sc., ... 7 Phillips Street.
Instructor in Agricultural Economics.

Charles H. Gould,[3] B.Sc., ... Kendrick Place.
Field Agent.

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[1] Resigned, to take effect Dec. 15, 1917.

[2] On leave of absence, war service.

[3] On leave of absence, with Hampshire County Farm Bureau.

LLOYD L. STEWART, B.Sc.Agr., ... 18 Nutting Avenue.
Instructor in Poultry Husbandry.

——— ——, ... – –
Assistant in Physics.

JOSEPH NOVITSKI, ... 30 Cottage Street.
Assistant in Rural Sociology.

THE EXPERIMENT STATION STAFF.

ADMINISTRATION.

WILLIAM P. BROOKS, Ph.D., ... 6 Farview Way.
Director.

JOSEPH B. LINDSEY, Ph.D., ... 47 Lincoln Avenue.
Vice-Director.

FRED C. KENNEY, ... Mount Pleasant.
Treasurer.

CHARLES R. GREEN, B.Agr., ... Mount Pleasant.
Librarian.

DEPARTMENT OF AGRICULTURAL ECONOMICS.

ALEXANDER E. CANCE, Ph.D., ... 9 Fearing Street.
In charge of Department.

SAMUEL H. DEVAULT, A.M., ... 39 East Pleasant Street.
Assistant.

DEPARTMENT OF AGRICULTURE.

WILLIAM P. BROOKS, Ph.D., ... 6 Farview Way.
Agriculturist.

HENRY J. FRANKLIN, Ph.D., ... Wareham.
In charge of Cranberry Investigation.

EDWIN F. GASKILL, B.Sc., ... North Pleasant Street.
Assistant Agriculturist.

ROBERT L. COFFIN, ... 19 Phillips Street.
Assistant.

DEPARTMENT OF BOTANY AND VEGETABLE PATHOLOGY.

A. VINCENT OSMUN, M.Sc., ... 16 Northampton Road.
Botanist.

GEORGE H. CHAPMAN, Ph.D., ... Fearing Street.
Research Physiologist.

PAUL J. ANDERSON, Ph.D., ... McClure Street.
Associate Plant Pathologist.

ORTON L. CLARK, B.Sc., ... 16 College Street.
Assistant Plant Physiologist.

WEBSTER S. KROUT, M.A., ... 46 Pleasant Street.
Field Pathologist.

DEPARTMENT OF ENTOMOLOGY.

HENRY T. FERNALD, Ph.D., ... 44 Amity Street.
Entomologist.

BURTON N. GATES, Ph.D., ... 42 Lincoln Avenue.
Apiarist.

ARTHUR I. BOURNE, A.B., ... 12 East Pleasant Street.
Assistant Entomologist.

STUART C. VINAL, M.Sc., ... 112 Pleasant Street.
Assistant in Entomology.

DEPARTMENT OF PLANT AND ANIMAL CHEMISTRY.

JOSEPH B. LINDSEY, Ph.D., ... 47 Lincoln Avenue.
Chemist.

EDWARD B. HOLLAND, Ph.D., ... 28 North Prospect Street.
Associate Chemist in charge of Research Division.

Fred W. Morse, M.Sc., ... 40 Pleasant Street.
Research Chemist.
Henri D. Haskins, B.Sc., ... 14 Amity Street.
In charge of Fertilizer Division.
Philip H. Smith, M.Sc., ... 102 Main Street.
In charge of Feed and Dairy Division.
Lewell S. Walker, B.Sc., ... 19 Phillips Street.
Assistant.
Carlton P. Jones, M.Sc., ... 8 Nutting Avenue.
Assistant.
Carlos L. Beals, M.Sc., ... 4 Kendrick Place.
Assistant.
James P. Buckley, B.Sc., ... 29 Lincoln Avenue.
Assistant.
Windom A. Allen,[1] B.Sc., ... – –
Assistant.
Bernard L. Peables, B.Sc., ... 4 Kendrick Place.
Assistant.
John B. Smith,[1] B.Sc., ... – –
Assistant.
Robert S. Scull,[1] B.Sc., ... – –
Assistant.
James T. Howard, ... 46 Pleasant Street.
Collector.
Harry L. Allen, ... 89 Main Street.
Assistant.
James R. Alcock, ... North Amherst.
Assistant.

Department of Horticulture.

Frank A. Waugh, M.Sc., ... Campus.
Horticulturist.
Fred C. Sears, M.Sc., ... Mount Pleasant.
Pomologist.
Jacob K. Shaw, Ph.D., ... 5 Farview Way.
Research Pomologist.

Department of Meteorology.

John E. Ostrander, A.M., C.E., ... 33 North Prospect Street.
Meteorologist.

Department of Microbiology.

Charles E. Marshall, Ph.D., ... 44 Sunset Avenue.
In charge of Department.
Arao Itano, Ph.D., ... 7 East Pleasant Street.
Assistant Professor of Microbiology.

Department of Poultry Husbandry.

John C. Graham, B.Sc.Agr., ... Lincoln Avenue.
In charge of Department.
Hubert D. Goodale, Ph.D., ... North Amherst.
Research Biologist.

Department of Veterinary Science.

James B. Paige, B.Sc., D.V.S., ... 42 Lincoln Avenue.
Veterinarian.
George E. Gage, Ph.D., ... 27 Sunset Avenue.
Associate Professor of Animal Pathology.
John B. Lentz,[1] V.M.D., ... – –
Assistant in Veterinary Science.
C. Theodore Buchholz,[2] V.M.D., ... – –
Assistant in Veterinary Science.

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[1] On leave of absence; war service.

[2] Resigned.

THE EXTENSION SERVICE STAFF.

William D. Hurd,[1] M.Agr., ... 46 Amity Street.
Director and Supervisor of Short Courses.
Austin D. Kilham, B.Sc.Agr., ... 12 Nutting Avenue.
Extension Assistant Professor of Pomology. Acting Director, 1917–18.
Sumner R. Parker, B.Sc., ... 51 Amity Street.
Extension Professor of Rural Organization and County Agent Leader.
George L. Farley, M.Sc., ... 31 Lincoln Avenue.
Supervisor of Junior Extension Work.
Ezra L. Morgan, A.M., ... 2 Allen Street.
Extension Professor of Community Planning.
Laura Comstock, ... 84 Pleasant Street.
Extension Professor of Home Economics and Leader of County Work for Women.
Alfred G. Lunn, B.Sc., ... North Amherst.
Extension Professor of Poultry Husbandry.
E. Farnham Damon, B.Sc., ... 35 South Pleasant Street.
Extension Associate Professor of Agricultural Economics.
Wesley H. Bronson,[2] B.Sc., ... – –
Extension Assistant Professor of Farm Demonstration.
William F. Turner, B.Sc., ... 37 Cottage Street.
Extension Assistant Professor of Animal Husbandry.
Frank A. C. Smith,[3] B.Sc., ... The Davenport.
Extension Assistant Professor of Landscape Gardening.
Marie Sayles,[1] B.Sc., ... 79 Pleasant Street.
Extension Assistant Professor of Home Economics.
Victor A. Rice, B.Sc.Agr., ... 24 Pleasant Street.
Extension Instructor in charge of Pig Club Work.
L. Wayne Arny, B.Sc., ... 7 Allen Street.
Supervisor of Correspondence Courses and Editor of Extension Service Publications.
Helen Norris, ... 16 Nutting Avenue.
Extension Instructor in Agricultural Education.
Bernard W. Shaper, B.Sc., ... 24 Pleasant Street.
Assistant to the Director.
Roswell W. Henninger,[2] B.Sc., ... – –
Extension Instructor in charge of Poultry Club Work.
Albert L. Dean,[4] . . . . 24 Pleasant Street.
Extension Instructor in charge of Poultry Club Work.
Ralph E. Van Meter,[4] B.Sc.Agr., ... 24 Pleasant Street.
Extension Instructor in Pomology.

THE CLERICAL STAFF.

Elbert L. Arnold, ... McClellan Street.
Chief Clerk, Extension Service.
Ella B. Baldwin, ... 73 Pleasant Street.
Clerk, Extension Service.
Eleanor F. Bishop, ... 3 Spaulding Street.
Bookkeeper, Treasurer's Office.
Evelyn Brewster, B.Sc., ... 16 Nutting Avenue.
Clerk, President's Office.
John K. Broadfoot, ... 7½ East Pleasant Street.
Cashier, Treasurer's Office.
Lena V. Chapman, ... 77 South Pleasant Street.
Library Assistant.
Lucia G. Church, ... North Amherst.
First Clerk, Experiment Station.

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[1] On leave of absence; service with United States Department of Agriculture.

[2] On leave of absence; war service.

[3] On leave of absence; war service from Jan. 1, 1918.

[4] Temporary appointment.

Bertha E. Connelly, ... Phillips Street.
Stenographer, Division of Rural Social Science.

Lalia M. Damon, ... 10 Nutting Avenue.
Cataloguer, Library.

Emily Davidson, ... 7 Northampton Road.
Telephone Operator, Stockbridge Hall.

Louise G. Davidson,[1] . . . . 7 Northampton Road.
Telephone Operator, Stockbridge Hall.

Llewelyn L. Derby,[2] . . . . 81 Pleasant Street.
Assistant, Department of Physical Education.

Hazel A. Dewar, ... 6 High Street.
Stenographer, Division of Agriculture.

Marion F. Dondale, A.B., ... 101 Butterfield Terrace.
Clerk, Graduate School and Department of Microbiology.

Noella Duval, ... 34 McClellan Street.
Clerk, Power Plant.

Margaret Evens, ... 73 Pleasant Street.
Stenographer, Extension Service.

F. Ethel Felton, A.B., ... 7 Allen Street.
Clerk and Editorial Assistant, Experiment Station.

Lina M. Fisher, ... 28 Pleasant Street.
Clerk, Department of Chemistry.

Grace E. Gallond, ... 28 Pleasant Street.
Clerk, Department of Dairying.

Margaret T. Gaskell, ... 105 Main Street.
Stenographer, Offices of Dean and Registrar

Lillian M. Gelinas, ... 77 Pleasant Street.
Clerk, President's Office.

Cora B. Grover, ... North Amherst.
Clerk, Extension Service.

Marion G. Guertin,[1] . . . . – –
Stenographer, Department of Beekeeping.

Lillian S. Hadfield, ... 16 Nutting Avenue.
Clerk, Extension Service.

Laura M. Hager, A.B., ... South Deerfield.
Clerk, Department of Agricultural Economics.

Mary G. Hanifin, ... Northampton.
Clerk, Division of Agriculture.

Mary E. Horton, ... 79 Pleasant Street.
Clerk, Department of Rural Sociology.

Alice M. Howard, ... North Amherst.
First Clerk, Experiment Station.

Marion M. Kelsey, ... Belchertown Road.
Clerk, Treasurer's Office.

Clarence E. Kendall, ... Hadley.
Mailing Clerk, Extension Service.

Ethel L. Kennedy, ... 8 Allen Street.
Clerk, Extension Service.

—— ——, ... – –
Stenographer, Department of Entomology.

Rachael G. Leslie, ... Allen Street.
Clerk, Department of Poultry Husbandry.

Grace MacMullen, A.B., ... 87 Pleasant Street.
Clerk, Department of Poultry Husbandry.

Irene A. Martin, ... 19 South East Street.
Stenographer, Treasurer's Office.

Rebecca L. Mellor, ... 10 Kellogg Avenue.
Clerk, Experiment Station.

Gladys I. Miner, ... South Deerfield.
Clerk, Extension Service.

Elisabeth E. Mooney, ... Northampton.
Clerk, Department of Poultry Husbandry.

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[1] Resigned.

[2] On leave of absence; war service from Dec. 8, 1917.

Marion Norton, A.B., Library Assistant.	87 Pleasant Street.
Bridie E. O'Donnell, Clerk, Department of Entomology.	Hadley.
Hazel Parker, Stenographer, Division of Horticulture.	North Amherst.
Helen C. Pomeroy, Clerk, Department of Floriculture.	North Amherst.
Frances Powers, Stenographer, Department of Dairying.	44 Lincoln Avenue.
Edith Robinson, Clerk, Department of Beekeeping.	South Deerfield.
Mary I. Shores, Clerk, Dean's Office.	35 South Pleasant Street.
Elizabeth Strachan, Clerk, Treasurer's Office.	17 High Street.
Ethelyn Streeter, Clerk, Division of Horticulture.	55 Amity Street.
Flora E. Torrey, Clerk, Extension Service.	21 North Prospect Street.
Ethel M. Turner, Library Assistant.	55 Pleasant Street.
Olive M. Turner, B.Sc., Clerk, Registrar's Office.	22 Spaulding Street.
Ellen L. Welch, A.B., Clerk, Department of Botany.	Hadley.
Aurelia B. Wentworth, First Clerk, Division of Agriculture.	South Amherst.
Mae Holden Wheeler, B.Sc., Curator, Department of Botany.	7 Phillips Street.

STAFF OF OPERATING AND MAINTENANCE.

John J. Barber, Farm Superintendent.	Campus.
Thomas Butterworth, Engineer.	3 Phillips Street.
John L. Byard, Superintendent of the Apiary.	21 Pleasant Street.
Lawrence S. Dickinson, B.Sc., Superintendent of Grounds.	2 Farview Way.
Clarence A. Jewett, Superintendent of Buildings.	112 Pleasant Street.
Ora L. Kennedy, Manager of the Dining Hall.	Draper Hall.
John J. Lee, Assistant to the Military Detail.	38 Cottage Street.
Florence Levensaler, Resident Nurse.	Infirmary.
George F. Pushee, Shop Assistant, Rural Engineering.	Northampton.
James Whiting, Foreman, Department of Floriculture.	16 Hallock Street.

GRADUATE ASSISTANTS.

Harry A. Cheplin,[1] Department of Microbiology.	– –
Frank N. Fagan, B.Sc.Agr., Department of Pomology.	75 Pleasant Street.
Thomas B. Gordon, B.Sc.Agr., Department of Agronomy.	24 Pleasant Street.

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[1] Resigned.

Louise Hompe, A.B., Department of Microbiology.	9 Phillips Street.
Conrad H. Lieber, B.Sc., Department of Microbiology.	– –
Ralph L. MacNeil, B.Sc., Department of Chemistry.	– –
James E. Martin,[1] Department of Microbiology.	– –
Satwaji G. Mutkekar, M.Sc., Department of Microbiology.	Draper Hall.
James M. Neill, B.Sc., Department of Microbiology.	15 Phillips Street.
William C. Pauley, B.Sc., Department of Landscape Gardening.	24 Pleasant Street.
James A. Purington, B.Sc., Department of Agronomy.	– –
George B. Ray, B.Sc., Department of Microbiology.	3 Nutting Avenue.
Donald White, A.B., Department of Botany.	24 Pleasant Street.
Carrick E. Wildon, B.Sc., Department of Floriculture.	66 Pleasant Street.
Elwin G. Wood,[1] B.Sc., Department of Pomology.	– –

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[1] Resigned.

STANDING COMMITTEES OF THE FACULTY.

1917–18.

CATALOGUE AND OTHER PUBLICATIONS.

Associate Professor NEAL.
Professor LOCKWOOD.
Secretary WATTS.

COMMENCEMENT.

Dean LEWIS.
Treasurer KENNEY.
Colonel WILSON.
Professor PETERS.
Associate Professor ROBBINS.
Secretary WATTS.
Assistant Professor HECHT.

COURSE OF STUDY.

President BUTTERFIELD.
Dean LEWIS.
Professor HART.
Professor WAUGH.
Professor FOORD.
Professor SPRAGUE.
Professor FERNALD.
Professor OSTRANDER.
Professor MARSHALL.
Professor CHAMBERLAIN.
Professor CANCE.
Associate Professor CHENOWETH.

DISCIPLINE (ADVISORY).

Dean LEWIS.
Registrar HASBROUCK.
Professor HICKS.
Professor PHELAN.
Professor GUNNESS.

EMPLOYMENT.

Professor SEARS.
Dean LEWIS.
Treasurer KENNEY.
Professor LOCKWOOD.
Professor MCNUTT.
Secretary WATTS.

ENTRANCE EXAMINATIONS AND ADMISSION.

Registrar HASBROUCK.
Dean LEWIS.
Professor OSMUN.
Associate Professor ASHLEY.
Assistant Professor PATTERSON.
Assistant Professor DUNCAN.
Mr. RAND.

HEALTH AND SANITATION.

Professor MARSHALL.
Treasurer KENNEY.
Colonel WILSON.
Professor HICKS.
Miss COMSTOCK.

LIBRARY.

Professor MARSHALL.
Professor SPRAGUE.
Professor GUNNESS.
Assistant Professor A. S. THOMSON.
Mr. GREEN.

SCHEDULE.

Professor LOCKWOOD.
Professor PETERS.
Assistant Professor DUNCAN.

SCHOLARSHIP.

Dean LEWIS.
Registrar HASBROUCK.
Professor CHAMBERLAIN.
Professor PHELAN.
Associate Professor MACKIMMIE.
Associate Professor ROBBINS.
Assistant Professor PATTERSON.
Mr. RAND.

STUDENT LIFE.

President BUTTERFIELD.
Dean LEWIS.
Treasurer KENNEY.
Director HURD.
Professor CHAMBERLAIN.
Professor SPRAGUE.
Professor HART.
Professor CRAMPTON.
Professor PHELAN.
Professor LOCKWOOD.
Professor GUNNESS.
Professor HICKS.
Associate Professor MACKIMMIE.
Associate Professor ROBBINS.
Secretary WATTS.
Associate Professor PAUL J. ANDERSON.
Assistant Professor HARRISON.
Assistant Professor PATTERSON.
Assistant Professor A. S. THOMSON.

UNCLASSIFIED STUDENTS.

Dean LEWIS.
  Professor WAUGH.
  Professor FOORD.
  Registrar HASBROUCK.
  Assistant Professor PATTERSON.

APPOINTED TO ATHLETIC BOARD.

Dean LEWIS.
  Registrar HASBROUCK.
  Professor OSMUN.

APPOINTED TO NON-ATHLETIC BOARD.

Professor LOCKWOOD.
  Assistant Professor PATTERSON.

THE COLLEGE.

ADMISSION.

A. APPLICATION FOR ADMISSION.

All correspondence concerning admission should be addressed to the registrar.

Every applicant for admission to the college must be at least sixteen years old, and must present to the registrar proper testimonials of good character. Such testimonials, whenever possible, should come from the principal of the school at which the applicant has prepared for college. Candidates who desire to present themselves for examination in any subjects must make application to the college for such privilege at least one month before examination is desired. Blanks for such application may be obtained by addressing the registrar of the college. All entrance credentials must be in the hands of the registrar before the applicant can matriculate.

B. MODES OF ADMISSION.

Students are admitted to the freshman class either upon certificate or upon examination. No *diploma* from a secondary school will be accepted.

CERTIFICATES. — Certificates will be received from those schools in New England which have been approved by the New England College Entrance Certificate Board. Principals of schools in New England who desire the certificate privilege should address the secretary of the Board, Professor Frank W. Nicolson, Wesleyan University, Middletown, Conn. Certificates from schools outside of New England may be received if those schools are on the approved list of the leading colleges of the section in which the school in question is located.

The credentials of the Board of Regents of the State of New York are accepted as satisfying the entrance requirements of this college when offered subject for subject.

Certificates in order to be accepted must present at least three of the necessary fourteen credits. It is to be understood, however, that responsibility for certification in either elementary French, elementary German, English 1 or English 2, Latin A, Greek A or algebra must be assumed by one school, if the candidate has received his preparation in any one subject named above in more than one school. Subjects lacking on certificate (except for the permitted number of conditions) must be made up at the time of the examinations for admission.

Blank forms for certification — sent to principals or school superintendents only — may be obtained on application to the registrar of the college.

EXAMINATIONS. — The examination in each subject may be oral or written, or both. The standard required for passing an examination for admission is 65 per cent. Conditions to the amount of two units will be allowed.

Entrance examination for admission to the Massachusetts Agricultural College will be held at the following centers: —

In June,	Amherst, Department of Physics building. Massachusetts Institute of Technology, Cambridge, Mass. Worcester, Horticultural Hall.
In September,	Amherst, Department of Physics building.

Please note that September examinations are held in Amherst only.

Schedule for Entrance Examinations, June 27-29, inclusive, 1918. — The examinations in June will follow this schedule: —

First Day.

7.45 A.M.	Registration.
8.00 A.M.	Plane geometry.
10.00 A.M.	Chemistry.
11.30 A.M.	Botany.
2.00 P.M.	Solid geometry.
4.00 P.M.	Physics.

Second Day.

8.00 A.M.	Required English.
11.00 A.M.	Algebra.
2.00 P.M.	History, required and elective.

Third Day.

8.00 A.M.	French, German, required and elective.
1.00 P.M.	Latin A and B and all one-half credit electives, except those already noted.

Schedule for Entrance Examinations in September. — In September, 1918, the examinations will be given September 18-21, inclusive, and will follow the order indicated below: —

First Day.

1.00 P.M.	Registration.
1.15-5.00 P.M.	Greek A and B.

Second Day.

8.00 A.M.	Plane geometry.
10.00 A.M.	Chemistry.
11.30 A.M.	Botany.
2.00 P.M.	Solid geometry.
4.00 P.M.	Physics.

Third Day.

8.00 A.M.	Required English.
11.00 A.M.	Algebra, agriculture.
2.00 P.M.	History, required and elective.

Fourth Day.

8.00 A.M.	French, German, required and elective.
1.00 P.M.	Latin A and B and all one-half credit electives, except those already noted.

C. Requirements for Admission.

The requirements for admission are based on the completion of a four-year high school course, or its equivalent, and are stated in terms of units. The term unit means the equivalent of at least four recitations a week for a school year. **Neither more nor less credit will be given in any subject than is indicated in the table below.** Fourteen units must be offered for admission. In the list given below, *every subject in black-faced type is prescribed and no substitution is allowed.* The subjects so typed total eight and one-half units. In addition to these points five and one-half more units must be chosen from the subjects printed in light-faced type. Not more than four half-credit units may be offered. No applicant deficient in both algebra and plane geometry will be admitted.

Agriculture, [1]	½ or 1 (or 3)*
Botany, [2]	½ or 1
Chemistry, [2]	1
Algebra,	1½
Plane geometry,	1
Solid geometry,	½
Trigonometry,	½
Physics, [2]	1
Geology,	½
Physiography,	½
Physiology,	½
Zoölogy, [2]	½
History [3] (Ancient; Medieval and Modern; English; General; United States and Civics), *any one*,	1 [4]
English 1,	1½
English 2,	1½
Modern Language (elementary French or elementary German),	2
Elementary French, [5]	2
Elementary German, [5]	2
Intermediate French,	1
Advanced French,	1
Intermediate German,	1
Advanced German,	1
Greek A, [1]	2
Greek B, [1]	1
Latin A,	2
Latin B,	1
Commercial geography, [6]	½
Drawing, [6]	½
Manual training, [6]	½ or 1

PRESENTATION OF NOTE-BOOKS. — The keeping of a note-book is required as part of the preparation in those subjects indicated (see note 2, below).

Candidates presenting themselves for examination in such subjects must present at the same time the required note-book, properly certified by the principal. Candidates presenting such subjects on certificates should not present note-books, but their certificates must state that note-books have been satisfactorily completed.

*** This additional entrance credit in agriculture may be allowed in individual cases, if recommended and authorized by the Division of Agriculture of the college. Early application to the head of the division is advisable, and schools likely to present such candidates are urged to correspond with this officer at once, that the necessary investigation and inspection may be made in time.**

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[1] Examination in September only.

[2] Note-book required as part of preparation will be credited as part of the examination.

[3] One must be offered for the required point; one, two or three others may be offered for elective points.

[4] For each offered.

[5] May be offered as elective if not offered to satisfy *prescribed* points.

[6] On certificate only, no examination given.

D. STATEMENT OF PREPARATION REQUIRED FOR ADMISSION.

AGRICULTURE. — Owing to the wide divergence of the methods of teaching agriculture in the public schools, the student will be required to bring a statement from the principal of the amount and kinds of work accomplished and of the text-books used. The examination will be based somewhat upon this information; but it will call for not less than one-half year of creditable work of high school grade. **The examination in agriculture will be given in September only.**

BOTANY. — For one unit of credit in botany, the work outlined in the statement of requirements issued by the College Entrance Examination Board, or its equivalent, will be accepted. This work should occupy one school year and include laboratory and supplementary text-book study. For one-half unit of credit, work that covers the same ground but occupies half the time required for a full unit of credit will be accepted. These requirements are met by such texts as Steven's "Introduction to Botany" and Bergen and Davis's "Principles of Botany." A note-book containing neat, accurate drawings and descriptive records forms part of the requirement for either the half-unit or the one-unit credit, and this note-book must be presented by all applicants for admission upon examination in this subject. The careful preparation of an herbarium is recommended to all prospective students of this college, although the herbarium is not required.

CHEMISTRY. — The entrance examination in chemistry will cover the work outlined by the College Entrance Examination Board as preparatory for college entrance. In general, this consists of a year of high school chemistry from such text-books as Newell's "Descriptive Chemistry" or Remsen's "Elements of Chemistry," with laboratory work on the general properties of the common elements. The keeping of a note-book is required.

MATHEMATICS. — (*a*) *Required.* — Algebra: The four fundamental operations for rational algebraic expressions; factoring, determination of highest common factor and lowest common multiple by factoring; fractions, including complex fractions; ratio and proportion; linear equations, both numerical and literal, containing one or more unknown quantities; problems depending on linear equations; radicals, including the extraction of the square root of polynominals and numbers; exponents, including the fractional and negative; quadratic equations, both numerical and literal; simple cases of equations with one or more unknown quantities that can be solved by the methods of linear or quadratic equations; problems depending upon quadratic equations; the binominal theorem for positive integral exponents, the formulas for the *n*th term and the sum of the terms of arithmetic and geometric progressions, with applications.

Plane Geometry: The usual theorems and constructions of good text-books, including the general properties of plane rectilinear figures; the circle and the measurement of angles; similar polygons; areas; regular polygons and the measurement of the circle; the solution of numerous original exercises, including loci problems; applications to the mensuration of lines and plane surfaces.

(*b*) *Elective.* — Solid Geometry: The usual theorems and constructions of good text-books, including the relations of planes and lines in space; the properties and measurement of prisms, pyramids, cylinders and cones; the sphere and spherical triangle; the solution of numerous original exercises, including loci problems; applications to the mensuration of surfaces and solids.

Plane Trigonometry: A knowledge of the definitions and relations of trigonometric functions and of circular measurements and angles; proofs of the principal formulas and the application of these formulas to the transformation of the trigonometric functions; solution of trigonometric equations, the theory and use of logarithms, and the solution of right and oblique triangles.

PHYSICS. — To satisfy the entrance requirement in physics, the equivalent of at least one unit of work is required. This work must consist of both class-room work and laboratory practice. The work covered in the class-room should be equal to that outlined in Hall & Bergen's "Text-book of Physics" or Millikan & Gale; the laboratory work should represent at least thirty-five experiments involving careful measurements, with accurate recording of each in laboratory note-book. This note-book, certified by the instructor in the subject, must be submitted by each candidate presenting himself for examination in physics; credit for passing the subject will be given on laboratory notes and on the examination paper submitted. Candidates entering on certificate will not be required to present note-books, but the principal's certification must cover laboratory as well as class-room work.

PHYSIOLOGY. — Hough & Sedgwick's "The Human Mechanism;" Martin's "The Human Body; Briefer Course."

ZOÖLOGY, PHYSIOGRAPHY, GEOLOGY. — The following suggestions are made concerning preparation for admission in the subjects named above: —

For physiography, Davis' "Elementary Physical Geography;" Gilbert & Brigham's "Introduction to Physical Geography." For zoölogy, text-books entitled "Animals" or "Animal Studies," by Jordan, Kellogg and Heath; Linville & Kelley's "A Text-book in General Zoölogy." For geology, A. P. Brigham's "A Text-book of Geology" or Tarr's "Elementary Geology."

Applicants for examination in zoölogy are *required* to present certified laboratory note-books; applicants for examination in the other subjects are *advised* to present note-books, if laboratory work has been done. Good note-books may be given credit for entrance. Examination in these subjects will be general, in recognition of the different methods of conducting courses; but students will be examined on the basis of the most thorough secondary school courses.

HISTORY. — The required unit must be offered in either ancient history, medieval and modern history, English history, general history, or United States history and civics. Either one, two or three elective units in any of the historical subjects here named may be offered, provided that no unit be offered in the same subject in which the required unit has been offered.

Preparation in history will be satisfactory if made in accordance with the recommendations of the committee of seven of the American Historical Association, as outlined by the College Entrance Examination Board. The examination will require comparisons and the use of judgment by the candidate rather than the mere use of memory, and it will presuppose the use of good text-books, collateral reading and practice in written work. Geographical knowledge may be tested by requiring the location of places and movements on outline maps.

To indicate in a general way the character of the text-book work expected, the texts of the following authors are suggested: Botsford, Morey or Myers, in ancient history (to 814 A.D.); Adams, West or Myers, in medieval history; Montgomery, Larned or Cheyney, in English history; Myers or Fisher, in general history; Fiske, together with MacLaughlin or Montgomery, in United States history and civics.

ENGLISH. — For 1916–19 inclusive: —

The study of English in school has two main objects: (1) command of correct and clear English, spoken and written; (2) ability to read with accuracy, intelligence and appreciation.

(1) *Grammar and Composition* (One and One-half Units). — The first object requires instruction in grammar and composition. English grammar should ordinarily be reviewed in the secondary school; and correct spelling and grammatical accuracy should be rigorously exacted in connection with all written work during the four years. The principles of English composition governing punctuation, the use of words, sentences and paragraphs should be thoroughly mastered; and practice in composition, oral as well as written, should extend throughout the secondary school period. Written exercises may well comprise letter-writing, narration, description and easy exposition and argument. It is advisable that subjects for this work be taken from the student's personal experience, general knowledge and studies other than English, as well as from his reading in literature. Finally, special instruction in language and composition should be accompanied by concerted effort of teachers in all branches to cultivate in the student the habit of using good English in his recitations and various exercises, whether oral or written.

(2) *Literature* (One and One-half Units). — The second object is sought by means of two lists of books, headed, respectively, "Reading" and "Study," from which may be framed a progressive course in literature covering four years. In connection with both lists the student should be trained in reading aloud and encouraged to commit to memory some of the more notable passages both in verse and in prose. As an aid to literary appreciation, he is further advised to acquaint himself with the most important facts in the lines of the authors whose works he reads and with their place in literary history.

A. Reading. — The aim of this course is to foster in the student the habit of intelligent reading and to develop a taste for good literature by giving him a first-hand knowledge of some of its best specimens. He should read the books carefully, but his attention should not be so fixed upon details that he fails to appreciate the main purpose and charm of what he reads.

With a view to large freedom of choice, the books provided for reading are arranged in the following groups, from each of which at least two selections are to be made, except as otherwise provided under Group I. : —

Group I. Classics in Translation: The "Old Testament," comprising at least the chief narrative episodes in Genesis, Exodus, Joshua, Judges, Samuel, Kings and Daniel, together with the books of Ruth and Esther; the "Odyssey," with the omission, if desired, of Books I., II., III., IV., V., XV., XVI., XVII.; the "Iliad," with the omission, if desired, of Books XI., XIII., XIV., XV., XVIII., XXI.; the "Æneid." The "Odyssey," "Iliad" and "Æneid" should be read in English translations of recognized literary excellence.

For any one selection from Group I. a selection from any other group may be substituted.

Group II. Shakspere: "Midsummer Night's Dream;" "Merchant of Venice;" "As You Like It;" "Twelfth Night;" "The Tempest;" "Romeo and Juliet;" "King John;" "Richard II.;" "Richard III.;" "Henry V.;" "Coriolanus;" "Julius Cæsar;"[1] "Macbeth;"[1] "Hamlet."[1]

Group III. Prose Fiction: Malory's "Morte d'Arthur" (about 100 pages); Bunyan's "Pilgrim's Progress," Part I.; Swift's "Gulliver's Travels" (voyages to Lilliput and to Brobdingnag); Defoe's "Robinson Crusoe," Part I.; Goldsmith's "Vicar of Wakefield;" Frances Burney's "Evelina;" Scott's novels, any *one;* Jane Austen's novels, any *one;* Maria Edgeworth's "Castle Rackrent" or "The Absentee;" Dickens' novels, any *one;* Thackeray's novels, any *one;* George Eliot's novels, any *one;* Mrs. Gaskell's "Cranford;" Kingsley's "Westward Ho!" or "Hereward the Wake;" Reade's "The Cloister and the Hearth;" Blackmore's "Lorna Doone;" Hughes's "Tom Brown's School Days;" Stevenson's "Treasure Island" or "Kidnapped" or "Master of Ballantrae;" Cooper's novels, any *one;* Poe's "Selected Tales;" Hawthorne's "The House of the Seven Gables" or "Twice Told Tales" or "Mosses from an Old Manse;" a collection of short stories by various standard writers.

Group IV. Essays, Biography, etc.: Addison and Steele's "The Sir Roger de Coverley Papers" or selections from the "Tatler" and "Spectator" (about 200 pages); selections from Boswell's "Life of Johnson" (about 200 pages); Franklin's "Autobiography;" selections from Irving's "Sketch Book" (about 200 pages) or "Life of Goldsmith;" Southey's "Life of Nelson;" selections from Lamb's "Essays of Elia" (about 100 pages); selections from Lockhart's "Life of Scott" (about 200 pages); Thackeray's "Lectures on Swift, Addison and Steele in the English Humorists;" Macaulay: any one of the following essays: "Lord Clive," "Warren Hastings," "Milton," "Addison," "Goldsmith," "Frederic the Great," "Madame d'Arblay;" selections from Trevelyan's "Life of Macaulay" (about 200 pages); Ruskin's "Sesame and Lilies" or "Selections" (about 150 pages); Dana's "Two Years Before the Mast;" Lincoln's "Selections," including at least the two inaugurals, the speeches in Independence Hall and at Gettysburg, the last public address, the letter to Horace Greeley, together with a brief memoir or estimate of Lincoln; Parkman's "The Oregon Trail;" Thoreau's "Walden;" Lowell's "Selected Essays" (about 150 pages); Holmes's "The Autocrat of the Breakfast Table;" Stevenson's "An Inland Voyage" and "Travels with a Donkey;" Huxley's "autobiography" and selections from "Lay Sermons," including the addresses on "Improving Natural Knowledge," "A Liberal Education" and "A Piece of Chalk;" a collection of "Essays" by Bacon, Lamb, De Quincey, Hazlitt, Emerson and later writers; a collection of "Letters" by various standard writers.

Group V. Poetry: Palgrave's "Golden Treasury" (first series), Books II. and III., with special attention to Dryden, Collins, Gray, Cowper and Burns; Palgrave's "Golden Treasury (first series), Book IV., with special attention to Wordsworth, Keats and Shelley (if not chosen for study under B); Goldsmith's "The Traveller" and "The Deserted Village;" Pope's "The Rape of the Lock;" a collection of English and Scottish ballads, as, for example, some "Robin Hood" ballads, "The Battle of Otterburn," "King Estmere," "Young Beichan," "Bewick and Grahame," "Sir Patrick Spens" and a selection from later ballads; Coleridge's "The Ancient Mariner," "Christabel" and "Kubla Khan;" Byron's "Childe Harold," Canto III. or IV., and "The Prisoner of Chillon;" Scott's "The Lady of the Lake" or "Marmion;"

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[1] If not chosen for study under B.

Macaulay's "The Lays of Ancient Rome," "The Battle of Naseby," "The Armada," "Ivry;" Tennyson's "The Princess" or "Gareth and Lynette," "Lancelot and Elaine" and "The Passing of Arthur;" Browning's "Cavalier Tunes," "The Lost Leader," "How They Brought the Good News from Ghent to Aix," "Home Thoughts from Abroad," "Home Thoughts from the Sea," "Incident of the French Camp," "Herve Riel," "Pheidippides," "My Lost Duchess," "Up at a Villa — Down in the City," "The Italian in England," "The Patriot," "The Pied Piper," "De Gustibus," "Instans Tyrannus;" Arnold's "Sohrab and Rustum" and "The Forsaken Merman;" selections from American poetry, with special attention to Poe, Lowell, Longfellow and Whittier.

B. Study. — This part of the requirement is intended as a natural and logical continuation of the student's earlier reading, with greater stress laid upon form and style, the exact meaning of words and phrases, and the understanding of allusions. The books provided for study are arranged in four groups, from each of which one selection is to be made.

Group I. Drama: Shakspere's "Julius Cæsar," "Macbeth," "Hamlet."

Group II. Poetry: Milton's "L'Allegro," "Il Penseroso" and either "Comus" or "Lycidas;" Tennyson's "The Coming of Arthur," "The Holy Grail" and "The Passing of Arthur;" the selections from Wordsworth, Keats and Shelley in Book IV. of Palgrave's "Golden Treasury" (first series).

Group III. Oratory: Burke's "Speech on Conciliation with America;" Macaulay's "Speech on Copyright" and Lincoln's "Speech at Cooper Union;" Washington's "Farewell Address" and Webster's "First Bunker Hill Oration."

Group IV. Essays: Carlyle's "Essay on Burns," with a selection from Burns's "Poems;" Macaulay's "Life of Johnson;" Emerson's "Essay on Manners."

Examination. — However accurate in subject-matter, no paper will be considered satisfactory if seriously defective in punctuation, spelling or other essentials of good usage.

The examination will be divided into two parts, one of which will be on grammar and composition, and the other on literature.

In grammar and composition, the candidate may be asked specific questions upon the practical essentials of these studies, such as the relation of the various parts of a sentence to one another, the construction of individual words in a sentence of reasonable difficulty, and those good usages of modern English which one should know in distinction from current errors. The main test in composition will consist of one or more essays, developing a theme through several paragraphs; the subjects will be drawn from the books read, from the candidate's other studies and from his personal knowledge and experience quite apart from reading.

The examination in literature will include: —

(*a*) General questions designed to test such a knowledge and appreciation of literature as may be gained by fulfilling the requirements defined under "A, Reading," above.

(*b*) A test on the books prescribed for study, which will consist of questions upon their content and structure, and upon the meaning of such words, phrases and allusions as may be necessary to an understanding of the works and an appreciation of their salient qualities of style. General questions may also be asked concerning the lives of the authors, their works and the periods of literary history to which they belong.

French. — Elementary: The necessary preparation for this examination is stated in the description of the two-year course in elementary French recommended by the Modern Language Association, contained in the definition of requirements of the College Entrance Examination Board.

Third and fourth year French (elective subjects for admission). — For a third credit unit in French as an elective subject for entrance, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For a fourth credit unit, the work described as "advanced" is expected.

No examination for a third unit in French will be given unless the candidate has presented elementary French on certificate, or has written the examination in elementary French.

No examination for a fourth credit in French will be given unless the candidate has presented both elementary and intermediate French upon certificate, or has written the examination in both elementary and intermediate French.

German. — Elementary: The entrance requirements in German conform to those of the College Entrance Examination Board for elementary German (the standard two-year requirements).

Third and fourth year German (elective subjects for admission). — For a third credit unit in German as an elective subject for entrance, when required units have been offered in German, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For a fourth credit unit, the work described as "advanced" is expected.

No examination for a third unit in German will be given unless the candidate has presented elementary German upon certificate, or has written the examination in elementary German.

No examination for a fourth credit in German will be given unless the candidate has presented both elementary and intermediate German upon certificate, or has written the examination for both elementary and intermediate German.

Greek. — Greek will receive credit as an elective requirement upon either examination or certification, as follows. **(The examination in Greek A and Greek B will be given in September only.)**

A. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from the first four books of Xenophon's "Anabasis," and (*b*) the translation of passages of Attic prose at sight.

B. A third credit unit will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages from the first six books of Homer's "Iliad," and (*b*) translation of passages of Homer's "Iliad" at sight, with questions on the form and constructions of the passages.

Latin. — Latin will receive credit as an elective requirement upon either examination or certification, as follows: —

A. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from Cæsar's "Gallic War," covering at least four books, and (*b*) the translation of passages of Latin prose at sight.

B. A third credit unit will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages selected from either Books I. to VI. of Virgil's "Æneid," or six orations of

Cicero, including those against Catiline; and (*b*) the translation into Latin prose of a passage of connected English narrative based on some portion of Cæsar's "Gallic War," Books I. to IV.

COMMERCIAL GEOGRAPHY.[1] — Preparation should be made in a course equivalent to that laid down in Adams' "Commercial Geography," Trotter's "Geography of Commerce," or a similar work. (No examination given.)

DRAWING.[1] — The applicant may offer either freehand or mechanical drawing or both. He must be able to make an accurate freehand sketch, in either outline or light and shade, of the appearance of a group of geometric solids, and have a sufficient knowledge of perspective to enable him to draw correctly a simple geometric model from memory; or, if he present mechanical drawing, he must have working familiarity with drawing instruments, and be able to make an accurate inked working drawing, in orthographic projection, of some simple object. Emphasis is laid on facility in doing good freehand lettering. For a limitation of the work that may be presented, see "Manual Training." (No examination given.)

MANUAL TRAINING.[1] — An entrance credit of one-half or one unit is allowed for manual training, on the presentation of a certificate from the principal of the school showing the scope and character of the applicant's work. The preparation may include mechanical drawing, working in wood, metals, leather, etc. When mechanical drawing is presented as a part of the work in manual training, no other credit for drawing will be allowed. No examination is given in this subject; applicants must present certificates to secure credit.

E. ADMISSION TO ADVANCED STANDING.

Candidates for admission to advanced standing, in addition to meeting the regular entrance requirements, must also pass examinations in those subjects already pursued by the class they desire to enter. To meet this requirement, a student transferring to this college from another college or university of recognized standing must present the following credentials: —

1. A letter of honorable dismissal from the institution with which he has been connected.
2. A statement or certificate of his entrance record.
3. A statement from the proper officer showing a complete record of his work while in attendance.
4. A marked catalogue showing the courses pursued.

These credentials should be presented to the registrar. Applications will be judged wholly on their merits and the college may prescribe additional tests before accepting applicants or determining the standing to be granted them.

F. OTHER INFORMATION ABOUT ENTRANCE.

1. The privileges of the college may be withdrawn from any student at any time if such action is deemed advisable. (It is immaterial whether the pupil has entered by certificate or by examination.)

2. The examination in each subject may be either oral or written, or both. The standard required for passing an entrance examination is 65 per cent.

3. Candidates must receive credit for twelve units out of the total number required for entrance, and will be conditioned in those subjects not passed.

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[1] On certificate only; no examination given.

Not more than five and one-half credits from the elective group will be accepted. No candidate deficient in both algebra and plane geometry will be admitted.

4. Examinations for the removal of entrance conditions will be held as follows: (1) First entrance condition examination during the first week of the second term. (2) Second entrance condition examination before the beginning of the period of final examinations of the second term, upon the payment of a fee of $5 to the treasurer.

5. Credits for entrance requirements, whether gained by certificate or by examination, will hold good for one year.

6. Examinations in part of the subjects required for entrance may be taken one year before entering college.

7. For information concerning expenses, scholarships, etc., see "General Information."

8. For information concerning admission to short courses see "Short Courses."

G. Unclassified Students.

All requests for information concerning admission of unclassified students should be addressed to Dean Edward M. Lewis, chairman of committee on unclassified students.

Students not candidates for a degree (unclassified students) are admitted under the following provisions: —

1. All unclassified students are subject to the supervision of a special committee.

2. No applicant under eighteen years of age will be admitted as an unclassified student.

3. No entrance examination is required, but applicants must bring certificates showing that they have finished a four-year high school course or its equivalent, or that they are graduates of a county agricultural school of Massachusetts, and furnish satisfactory testimonials as to moral character.

4. No student of this or any other institution who has not done efficient work therein shall be permitted to register as an unclassified student.

5. Each unclassified student must take from the regular technical elective courses, and necessary prerequisites, a minimum of twelve credit hours a week.

6. In order to be admitted to any course, an unclassified student must have had all prerequisite subjects for that course.

7. Every unclassified student must do all the work of the courses elected, and take all examinations therein. In order to pass such courses he must attain a grade of at least 60 per cent. An unclassified student who passes in less than 60 per cent. of his work will be dropped from college.

8. Any unclassified student may be dropped from college at any time if his presence in any class is undesirable or his work is unsatisfactory; and no unclassified student will be allowed to remain in college more than six terms without the special permission of the faculty.

9. No unclassified student shall be allowed to participate in any intercollegiate contests.

10. Unclassified students are subject to the general regulations applying to classified students.

11. Every unclassified student should clearly understand that before any application for transfer to the regular registration for the Bachelor of Science degree will be considered by the registrar, he must present all entrance credits either by certificate or by examination in the same way as is required of a student who enters regularly.

H. One-year Vocational Course in Poultry Husbandry.

Purpose. — This course is designed for graduates of the agricultural vocational schools and others who wish to prepare themselves for practical poultry keeping and can spend only one year at college.

Scope. — The work covers seven detailed courses in poultry husbandry, as well as short-course work in fruit growing, market gardening, bee culture, animal husbandry or other subjects that will be helpful to poultry raisers. In addition to classroom and laboratory exercises each student is required to put in from 25 to 30 hours per week at the plant in the care and management of poultry for the purpose of becoming proficient in the various branches of the work.

Entrance Requirements. — Applicants must be at least eighteen years of age and have a good elementary education.

Fees. — There is no tuition for residents of Massachusetts, but a laboratory fee of $5 is required for both the fall and spring terms.

Note. — The course is limited to 16 students.

COURSES OF INSTRUCTION.

TABLE OF FRESHMAN AND SOPHOMORE SUBJECTS.

[The figures indicate the number of credit hours a week. For details, see the descriptions of courses.]

FRESHMAN YEAR.

FIRST TERM.

All work required.

SUBJECT.	Courses and Numbers.	Credit Hours per Week.
Chemistry,	Chemistry 1 or 4,	3
Algebra,	Mathematics 1,	5
Language,	French or German 1 or 4,	3
English,	English 1,	3
Agriculture,	Agronomy 1,	3
Tactics,	Military 1,	1
Drill,	Military 4,	2
Hygiene,	Physical Education 1,	1
Public speaking,	Public Speaking 1 (one-third of the class),	1
		22

College life (attendance without credit).

SECOND TERM.

Chemistry,	Chemistry 2 or 5,	3
Algebra,	Mathematics 2,	2
Trigonometry,	Mathematics 5,	3
Language,	French or German 2 or 5,	3
English,	English 2,	3
Agriculture,	Agronomy 1, Animal Husbandry 1,	3
Tactics,	Military 2,	1
Drill,	Military 5,	1
Geology,	Geology 2,	2
Public speaking,	Public Speaking 1 (one-third of class),	1
		22

College life (attendance without credit).

FRESHMAN YEAR — *Concluded.*

THIRD TERM.

SUBJECT.	Courses and Numbers.	Credit Hours per Week.
Chemistry,	Chemistry 3 or 6,	3
Agriculture,	Agronomy 1,	3
Solid geometry,	Mathematics 3,	3
Mensuration,	Mathematics 6,	2
Language,	French or German 3 or 6,	3
English,	English 3,	3
Botany,	Botany 3,	3
Tactics,	Military 3,	1
Drill,	Military 6,	2
Recreation,	Physical Education 3,	1
Public speaking,	Public Speaking 1 (one-third of class),	1
		25

College life (attendance without credit).

SOPHOMORE YEAR.

FIRST TERM.

SUBJECT.	Course Number.	Class Hours.	Two Hour Laboratory Periods.	Credit Hours per Week.
Required.				
Physics,	25	3	1	4
Zoölogy,	25	2	2	4
Botany,	25	1	2	3
English,	25	2	–	2
Military,	25	1	–	1
Military,	28	–	2	2
Total required,	–	–	–	16
Elective.				
Chemistry,	25	1	2	3
French,	25 or 28	3	–	3
German,	25 or 28	3	–	3
Drawing,	25	–	3	3
Animal husbandry,	25	2	1	3
Rural engineering,	25	–	2	2

SOPHOMORE YEAR — *Concluded.*

SECOND TERM.

SUBJECT.	Course Number.	Class Hours.	Two Hour Laboratory Periods.	Credit Hours per Week.
Required.				
Physics,	26	2	1	3
Agricultural economics,	26	5	–	5
English,	26	2	–	2
Military,	26	1	–	1
Military,	29	–	2	1
	–	–	–	12
Elective.				
Chemistry,	26	1	2	3
French,	26 or 29	3	–	3
German,	26 or 29	3	–	3
Mathematics,	26	2	–	2
Drawing,	26	–	3	3
Entomology,	26	3	–	3
Animal husbandry,	26	1	2	3
Rural engineering,	26	–	2	2
Botany,	26	1	2	3
Economic sociology,	26	5	–	5

THIRD TERM.

Required.				
Rural sociology,	27	3	–	3
Agronomy,	27	4	1	5
English,	27	2	–	2
Military,	27	1	–	2
Military,	30	–	2	2
Physical education,[1]	26	–	1	1
Total required,	–	–	–	15
Elective.				
Chemistry,	27	1	4	5
Chemistry,	30	3	2	5
French,	27 or 30	3	–	3
German,	27 or 30	3	–	3
Mathematics,	27	–	3	3
Drawing,	27	–	3	3
Entomology,	27	–	2	2
Geology,	27	3	2	5
Physics,	27	4	1	5
Horticulture,	27	2	1	3
Zoölogy,	27	1	2	3

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[1] Credit for Physical Education 2 and 3 given in third term.

MAJORS: JUNIOR AND SENIOR YEARS.

General Statement.

A major consists of 45 credit hours of correlated work, to be arranged by the student and an instructor called the adviser.

The list of courses found under each major on subsequent pages should not be considered as necessarily a rigid program to be followed. The heads of departments have suggested this series of courses as the best for the average man majoring in their departments. Advisers may, however, make modifications to suit the particular needs of the student, provided these modifications conform precisely to the class schedule as published for the year.

Rules governing Majors.

Rule 1. *Election.* — Each student, before the first term of his junior year, shall elect a major subject from the list of majors given below; and this major shall consist of 45 credit hours of correlated work.

Rule 2. *Minimum Credits.* — The minimum number of credits for graduation shall be 234 credit hours, inclusive of military drill and physical education.

Rule 3. *Maximum Credits.* — The maximum number of credits for any term of the junior or senior year shall be 22; the minimum shall be 19.

Rule 4. *Humanities and Rural Social Science.* — A minimum of 18 credit hours in the Divisions of the Humanities and Rural Social Science will be required of all students during their junior and senior years, with the following restriction: that a minimum of 5 credit hours will be required in each of the divisions, except that the minimum for the class of 1918 shall be 22 hours.

Rule 5. *Advisers.* — The work of each junior and senior will be under the immediate supervision of an instructor designated as major adviser. Ordinarily, the major adviser will be the head of the department in which the student intends to elect his major. Each student should consult with the adviser as soon as possible. The adviser has full authority to prescribe the student's work up to 45 hours. It is understood, however, that so far as practicable the individual needs of the student will be recognized. It is also hoped and expected that students will be disposed to seek the counsel of the adviser with respect to the remaining courses required for graduation.

Rule 6. *Free Electives.* — Each student during his junior and senior years is required to take 45 hours in his major and also 18 hours in the Divisions of the Humanities and Rural Social Science, making a total of 63 hours (but see Rule 4). He is allowed free choice of courses to complete his required hours.

Rule 7. *Registration.* — No junior or senior shall register until his major course of study is approved by his adviser.

(1) Course cards for recording the election of majors will be issued from the registrar's office three weeks before the close of each term.

(2) This card must be submitted by each student to his major adviser, who will lay out the course for the succeeding term and countersign the card.

(3) Each course card must be filled out, giving the name of student, his college address, the name of parent or guardian, and the student's home address. When the major courses have been entered on this card, and the hours

of free elections added by the student, the card must be returned to the registrar one week before the beginning of the final examination period.

Rule 8. *Changes.* — Applications for changes may be made to the dean in writing at any time; when approved by him and by the committee on scholarship, they become operative at the beginning of the term following, provided that no change in the selection of a major may be made by any student after registration day of his senior year.

AGRICULTURE. (Major.)

Professor JAMES A. FOORD, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.
Agronomy,	50 **I.**	5
Agronomy,	76 **III.**	5
Animal Husbandry,	51 **III.**	3
Animal Husbandry,	75 **I.**	3
Animal Husbandry,	76 **II.**	3
Dairying,	50 **I.**	5
Farm Management,	75 **II.**	3
Farm Management,	76 **III.**	5
Microbiology,	50 **I.**	
or		5
Microbiology,	50 **III.**	
Rural Engineering,	75 **I.**	5
		42

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Animal Husbandry 25,	3	Agronomy 50,	5	Animal Husbandry 75,	3
	Rural Engineering 25,	2	Dairying 50,	5	Rural Engineering 75,	5
II.	Mathematics 26,	2			Farm Management 75,	3
	Animal Husbandry 26,	3			Animal Husbandry 76,	3
	Rural Engineering 26,	2				
III.	Chemistry 30,	5	Microbiology 50,	5	Agronomy 76,	5
	Mathematics 27,	3	Animal Husbandry 51,	3	Farm Management 76,	5
	Horticulture 27,	3				
IV.						

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — Animal Husbandry 25 and 26, Rural Engineering (shop work) 25 and 26, Chemistry 30, Mathematics 26 and 27, and Horticulture 27.

ADDITIONAL INFORMATION. — Dairying 75, Pomology 50 and 51, Rural Engineering 78, and Veterinary 51 and 78 are suggested as additional courses for the student fitting himself for general agriculture.

AGRONOMY. (Major.)

Associate Professor ARTHUR B. BEAUMONT, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Agronomy,	50 **I.**	5	**I.**	Chemistry 25,	3	Agronomy 50,	5	Agronomy 75,	3
Agronomy,	51 **III.**	5		German 25 or 28,	3	Chemistry 51,	8	Animal Husbandry 75,	5
Agronomy,	75 **I.**	5							
Agronomy,	77 **II.**	5	**II.**	Botany 26,	3	Chemistry 52,	8	Agronomy 77,	5
Animal Husbandry,	75 **I.**	3		Chemistry 26,	3				
Chemistry,	51 **I.**	8		German 26 or 29,	3				
				Mathematics 26,	2				
Chemistry,	52 **II.**	8	**III.**	German 27 or 30,	3	Agronomy 51,	5	Farm Management 76,	5
Farm Management,	76 **III.**	5		Mathematics 27,	3				
				Geology 27,	5				
		44							
			IV.						

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — Chemistry 25 and 26, German 25 or 28, 26 or 29, 27 or 30, Geology 27, Botany 26.
ADVISED. — Mathematics 26 and 27.

ANIMAL HUSBANDRY. (Major.)

Professor JOHN C. MCNUTT, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Agronomy,	50 **I.**	5	**I.**	Animal Husbandry 25,	3	Agronomy 50,	5	Animal Husbandry 75,	3
Animal Husbandry,	51 **III.**	3				Veterinary 50,	5		
Animal Husbandry,	50 **II.**	1				Dairying 50,	5		
Animal Husbandry,	52 **III.**	3	**II.**	Animal Husbandry 26,	3	Animal Husbandry 50,	1	Animal Husbandry 76,	3
Animal Husbandry,	75 **I.**	3						Animal Husbandry 78,	3
Animal Husbandry,	76 **II.**	3						Farm Management 75,	3
Animal Husbandry,	77 **III.**	3	**III.**	Chemistry 30,	5	Animal Husbandry 51,	3	Animal Husbandry 80,	1
Animal Husbandry,	78 **II.**	3				Animal Husbandry 52,	3	Animal Husbandry 77,	3
Animal Husbandry,	80 **III.**	1						Farm Management 76,	5
Dairying,	50 **I.**	5	**IV.**						
Farm Management,	75 **II.**	3							
Farm Management,	76 **III.**	5							
Veterinary,	50 **I.**	5							
		43							

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — Animal Husbandry 25 and 26, Chemistry 30.

ADDITIONAL INFORMATION. — The balance of the sophomore electives allowed are left to the student to choose.

DAIRYING. (Major.)

Professor WILLIAM P. B. LOCKWOOD, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Animal Husbandry,	52 **III.**	3	**I.**	Animal Husbandry 25,	3	Dairying 50,	5	Animal Husbandry 75,	3
Animal Husbandry,	75 **I.**	3		Rural Engineering 25,	2	Microbiology 50,	5	Microbiology 82,	5
Animal Husbandry,	76 **II.**	3							
Dairying,	50 **I.**	5	**II.**	Animal Husbandry 26,	3	Rural Engineering 77,	5	Farm Management 75,	3
Dairying,	51 **III.**	5		Rural Engineering 26,	2	Microbiology 51,	5	Animal Husbandry 76,	3
Dairying,	75 **II.**	5				(Prerequisite to 82.)		Dairying 75,	5
Dairying,	76 **III.**	5	**III.**	Chemistry 30,	5	Animal Husbandry 52,	3	Dairying 76,	5
Farm Management,	75 **II.**	3				Dairying 51,	5		
Microbiology,	50 **I.**	5							
Microbiology,	82 **I.**	5							
Rural Engineering,	77 **II.**	5	**IV.**						
		47							

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — Animal Husbandry 25 and 26, Rural Engineering 25 and 26, Chemistry 30.

ADDITIONAL INFORMATION. — The balance of the sophomore electives allowed are left to the student to choose.

POULTRY HUSBANDRY. (Major.)

Professor JOHN C. GRAHAM, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Agricultural Economics,	75 **I.**	5	**I.**			Poultry 50,	3	Poultry 76,	5
Animal Husbandry,	51 **III.**	3				Poultry 51,	2	Poultry 77,	5
Poultry Husbandry,	50 **I.**	3				Agricultural Economics 75,	5	Pomology 50,	3
Poultry Husbandry,	51 **I.**	2	**II.**			Poultry 52,	3	Poultry 75,	5
Poultry Husbandry,	52 **II.**	3						Veterinary 86,	3
Poultry Husbandry,	53 **III.**	5							
Poultry Husbandry,	54 **III.**	2	**III.**			Poultry 53,	5		
Poultry Husbandry,	75 **II.**	5				Poultry 54,	2		
Poultry Husbandry,	76 **I.**	5				Animal Husbandry 51,	5		
Poultry Husbandry,	77 **I.**	5	**IV.**						
Pomology,	50 **I.**	3							
Veterinary Science,	86 **II.**	3							
		44							

SOPHOMORE RECOMMENDATIONS. — Students intending to major in Poultry Husbandry are urged to take Zoölogy 27.

ADVISED. — Juniors who did not take Zoölogy 27 as sophomores are strongly advised to include it in their program.

FLORICULTURE.

Assistant Professor AUGUST G. HECHT, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.
Botany,	50 **I.**	2
Botany,	51 **II.**	2
Entomology,	26 **II.**	3
Floriculture,	50 **I.**	4
Floriculture,	51 **II.**	4
Floriculture,	52 **III.**	4
Floriculture,	53 **I.**	3
Floriculture,	54 **II.**	3
Floriculture,	75 **I.**	3
Floriculture,	76 **II.**	3
Floriculture,	77 **II.**	3
Floriculture,	78 **III.**	3
Floriculture,	80 **III.**	3
Horticulture,	50 **I.**	5
Horticulture,	51 **III.**	5
		50

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Drawing 25,	3	Floriculture 50,	4	Floriculture 75,	3
			Floriculture 53,	3	Horticulture 50,	5
			Botany 50,	2		
II.	Drawing 26,	3	Floriculture 51,	4	Floriculture 77,	3
	Entomology 26,	3	Floriculture 54,	3	Floriculture 76,	3
	Botany 26,	3	Entomology 26,	5		
			Botany 51,	2		
III.	Drawing 27,	3	Floriculture 52,	4	Floriculture 80,	3
	Entomology 27,	2	Floriculture 78,	3	Horticulture 51,	5
	Horticulture 27,	3				
IV.						

SOPHOMORE ELECTIVE PREREQUISITES. — Drawing 25, 26 and 27, Entomology 26 and 27, Botany 26 and Horticulture 27.

ADDITIONAL INFORMATION. — The rest of the sophomore electives allowed are left to the student to choose. Horticulture 50 and 51 will be taken by seniors.

ADVISED. — The department advises all students who major in this subject to take Botany 78 and Landscape Gardening 75.

FORESTRY. (Major.)

Professor WILLIAM D. CLARK, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Botany,	50 **I.**	2	**I.**	Drawing 25,	3	Forestry 50,	3	Forestry 75,	5
Botany,	50 **II.**	2		Rural Engineering 25,	2	Landscape Gardening 50,	5		
Entomology,	75 **III.**	4				Horticulture 50,	5		
						Botany 50,	2		
Forestry,	50 **I.**	3	**II.**	Drawing 26,	3	Forestry 51,	3		
Forestry,	51 **II.**	3		Mathematics 26,	2	Botany 51,	2		
Forestry,	53 **III.**	3		Entomology 26,	3	Landscape Gardening 51,	4		
Forestry,	54 **IV.**	5		Botany 26,	3				
Forestry,	75 **I.**	5	**III.**	Drawing 27,	3	Forestry 53,	3	Forestry 78,	3
Forestry,	78 **III.**	3		Mathematics 27,	2	Horticulture 51,	5		
Horticulture,	50 **I.**	5		Entomology 27,	3	Entomology 75,	4		
				Horticulture 27,	3				
Horticulture,	51 **III.**	5	**IV.**			Landscape Gardening 53,	5		
Landscape Gardening,	50 **I.**	5				Forestry 54,	5		
Landscape Gardening,	51 **II.**	4							
		49							

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — Drawing 25, 26 and 27, Rural Engineering 25, Mathematics 26 and 27, Entomology 26 and 27, Botany 26, Horticulture 27.

ADDITIONAL INFORMATION. — Substitutions according to individual needs may be made in conference with the adviser.

LANDSCAPE GARDENING. (Major.)

Professor FRANK A. WAUGH, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Horticulture,	50 **I.**	5	**I.**	Drawing 25,	3	Landscape Gardening 50,	5	Landscape Gardening 75,	3
Horticulture,	51 **III.**	5				Horticulture 50,	5		
Landscape Gardening,	50 **I.**	5				Drawing 25,	3		
Landscape Gardening,	51 **II.**	4	**II.**	Drawing 26,	3	Landscape Gardening 51,	4	Landscape Gardening 76,	4
Landscape Gardening,	52 **III.**	5		Mathematics 26,	2	Drawing 26,	3		
Landscape Gardening,	53 **IV.**	5		Entomology 26,	3				
Landscape Gardening,	75 **I.**	3	**III.**	Drawing 27,	3	Landscape Gardening 52,	5	Landscape Gardening 78 or 79,	3
Landscape Gardening,	76 **II.**	4		Mathematics 27,	3	Horticulture 51,	5	Landscape Gardening 77,	4
Landscape Gardening,	77 **III.**	4		Horticulture 27,	3	Drawing 27,	3		
						Landscape Gardening 78 or 79,	3		
Landscape Gardening, or	78 **III.**	3	**IV.**			Landscape Gardening 53,	5		
Landscape Gardening,	79 **III.**	3							
		46							

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — Drawing 25, 26 and 27, Mathematics 26 and 27, Horticulture 27.

ADDITIONAL INFORMATION. — Modifications may be permitted when they appear advisable.

POMOLOGY. (Major.)

Professor FRED C. SEARS, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Agronomy,	75 **I.**	5	**I.**			Pomology 50,	3	Pomology 75,	3
Agronomy,	77 **II.**	5				Rural Engineering 76,	5	Pomology 77,	5
Rural Engineering,	76 **I.**	5						Pomology 80,	1
Farm Management,	75 **II.**	3						Agronomy 75,	5
Pomology,	50 **I.**	3	**II.**			Pomology 51,	3	Pomology 76,	3
						Farm Management 75,	3	Pomology 81,	1
								Agronomy 77,	5
Pomology,	51 **II.**	3	**III.**	Horticulture 27,	3	Pomology 52,	3	Pomology 78,	3
Pomology,	52 **III.**	3						Pomology 82,	1
Pomology,	75 **I.**	3							
Pomology,	76 **II.**	3	**IV.**			Pomology 53,	5		
Pomology,	77 **I.**	5							
Pomology,	78 **III.**	3							
Pomology,	80 **I.**	1							
Pomology,	81 **II.**	1							
Pomology,	82 **III.**	1							
		44							

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — Horticulture 27.

ADVISED. — Rural Engineering 26, Entomology 26 and 27.

ADDITIONAL INFORMATION. — The rest of the sophomore electives allowed are left to the student to choose.

ECONOMIC BOTANY. (Major.)

Professor A. VINCENT OSMUN, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Botany,	52 **I.**	3	**I.**	Chemistry 25,	3	Botany 52,	3	Botany 75,	5
Botany,	53 **II.**	3		German 25 or 28,	3	Botany 55,	3	Botany 78,	5
Botany,	54 **III.**	3				Chemistry 51,	8	Botany 86,	1
Botany,	55 **I.**	3							
Botany,	56 **II.**	3							
Botany,	75 **I.**	5	**II.**	Chemistry 26,	3	Botany 53,	3	Botany 76,	5
Botany,	76 **II.**	5		German 26 or 29,	3	Botany 56,	3	Botany 79,	5
Botany,	77 **III.**	5		Botany 26,	3			Botany 82,	3
Botany,	78 **I.**	5						Botany 87,	1
Botany,	79 **II.**	5							
Botany,	80 **III.**	5							
Botany,	82 **II.**	3	**III.**	German 27 or 30,	3	Botany 54,	3	Botany 77,	5
Botany,	83 **III.**	3						Botany 80,	5
Botany,	86 **I.**	1						Botany 83,	3
Botany,	87 **II.**	1						Botany 88,	1
Botany,	88 **III.**	1							
Chemistry,	51 **I.**	8							
		62							
			IV.						

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — German 25 or 28, 26 or 29, 27 or 30, Botany 26.

ADVISED. — Chemistry 25 and 26.

ADDITIONAL INFORMATION. — The balance of the sophomore electives allowed are left to the student to choose.

Selection of 45 credits of the above (Pathology 75, 76 and 77, Physiology 78, 79 and 80.)

AGRICULTURAL CHEMISTRY. (Major.)

Professor CHARLES A. PETERS, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.
Chemistry,	51 **I.**	8
Chemistry,	52 **II.**	8
Chemistry,	60 **I.**	3
Chemistry,	61 **II.**	3
Chemistry,	62 **III.**	5
Chemistry,	65 **III.**	5
Chemistry,	76 **I.**	5
Chemistry,	77 **II.**	3
Chemistry,	80 **I.**	5
Chemistry,	87 **III.**	3
Chemistry,	90 **II.**	3[1]
Chemistry,	92 **II.**	
Chemistry,	94 **II.**	
Chemistry,	91 **III.**	5
Chemistry,	93 **II.**	
Chemistry,	95 **III.**	
		54[2]

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Chemistry 25, German 25 or 28,	3 3	Chemistry 51, Chemistry 60,	8 3	Chemistry 76, Chemistry 80,	5 5
II.	Chemistry 26, German 26 or 29, Entomology 26,	3 3 3	Chemistry 52, Chemistry 61,	8 3	Chemistry 77, Chemistry 90, 92, 94,	3 3[2]
III.	Chemistry 27, German 27 or 30, Entomology 27,	5 3 2	Chemistry 62, Chemistry 65,	5 5	Chemistry 91, 93, 95, Chemistry 87,	5 3
IV.						

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — Chemistry 25, 26 and 27.

ADVISED. — German 25 or 28, 26 or 29, 27 or 30, Entomology 26 and 27.

ADDITIONAL INFORMATION. — The balance of the sophomore electives allowed are left for the student to choose.

[1] Courses 90, 92, 94 may be changed from 3 credits to an option of 3 or 5 credits.

[2] To get the allowed 45 credits the student will select one of the following groups of courses: 90 and 91, or 92 and 93, or 94 and 95, together with the balance from courses shown above.

ECONOMIC ENTOMOLOGY. (Major.)

Professor HENRY T. FERNALD, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Botany,	50 **I.**	2	**I.**	French 25–28, or German 25–28,	3	Botany 50,	2	Entomology 76,	5
Botany,	51 **II.**	2		Chemistry 25,	3	Zoölogy 50,	3		
Entomology,	50 **I.**	3				Entomology 50,	3		
Entomology,	51 **II.**	3							
Entomology,	52 **III.**	3							
Entomology,	75 **III.**	4	**II.**	French 26–29, or German 26–29,	3	Zoölogy 51,	3	Entomology 77,	3
Entomology,	76 **I.**	5		Entomology 26,	3	Entomology 51,	3	Zoölogy 76,	3
Entomology,	77 **II.**	3		Botany 26,	3	Botany 51,	2	Entomology 90,	3
						Chemistry 61,	3		
Entomology,	78 **III.**	4	**III.**	French 27–30, or German 27–30,	3	Zoölogy 52,	3	Entomology 78,	4
Entomology,	90 **II.**	3		Entomology 27,	2	Entomology 55,	3	Entomology 75,	4
Zoölogy,	50 **I.**	3		Chemistry 27,	5				
Zoölogy,	51 **II.**	3	**IV.**						
Zoölogy,	52 **III.**	3							
Zoölogy,	54 **II.**	3							
		38							

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — Entomology 26 and 27, Botany 26.

ADVISED. — French or German 25 or 28, 26 or 29, 27 or 30, Chemistry 25, 27 and 61.

ADDITIONAL INFORMATION. — The balance of the sophomore electives allowed are left for the student to choose. Juniors are advised to take Entomology 60. In 1916-17 Entomology 26 and 27 will be taken by juniors as part of their major. Beginning 1917-18 the regular junior courses 50, 51 and 52 will be in operation.

MICROBIOLOGY. (Major.)

Professor CHARLES E. MARSHALL, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.
Chemistry,	51 **I.**	8
Chemistry,	52 **II.**	8
Microbiology, or Microbiology,	50 **I.** 50 **III.**	5
Microbiology, or Microbiology, or Microbiology,	51 **I.** 51 **II.** 51 **III.**	5
Microbiology,	52 **III.**	5
Microbiology, or Microbiology, or Microbiology,	81 **I.** 82 **I.** 83 **I.**	5
Microbiology, or Microbiology, or Dairying,	80 **II.** 75 **II.** 75 **I.**	5
		41

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Chemistry 25, German or French 25 or 28,	3 3	Microbiology 50, Microbiology 51, Chemistry 51,	5 5 8	Microbiology 81, Microbiology 82, Microbiology 83,	5 5 5
II.	German or French 26 or 29,	3	Microbiology 51, Chemistry 52,	5 8	Microbiology 75, Microbiology 80, Dairying 75,	5 5 5
III.	Chemistry 27, German or French 27 or 30, Physics 27,	5 3 5	Microbiology 50, Microbiology 51, Microbiology 52,	5 5 5	Microbiology 76,	5
IV.						

SOPHOMORE ELECTIVE (RECOMMENDATIONS). — German or French 25 or 28, 26 or 29, 27 or 30, Chemistry 25 and 27, and Physics 27.

ADDITIONAL INFORMATION. — The rest of the sophomore electives allowed are left for the student to choose. Microbiology 51, fall term, will be taken by students who have had Microbiology 50 the preceding spring, and by those who are permitted to omit Microbiology 50.

RURAL JOURNALISM. (Major.)

Associate Professor ROBERT W. NEAL, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Rural Journalism,	50 **I.**	3	**I.**			Journalism 50,	3	Journalism 77,	3
Rural Journalism,	51 **II.**	3				[Journalism 53,	3]	Journalism 80,	4 (5)
						Agricultural Economics 51,	5		
Two out of three: —									
[Rural Journalism,	53 **I.**	3]	**II.**	Economics and Sociology 26,	5	Journalism 51,	3	Journalism 77,	3
Rural Journalism,	54 **II.**	3				Journalism 54,	3	Journalism 81,	4 (5)
Rural Journalism,	55 **III.**	3				Economics and Sociology 51,	5		
Two out of three: —									
Rural Journalism,	77 **I.**	3	**III.**			Journalism 55,	3	[Journalism 77,	3]
Rural Journalism,	78 **II.**	3						Journalism 82,	4 (5)
Rural Journalism,	79 **III.**	3							
All: —									
Rural Journalism,	80 **I.**	4 (5)							
Rural Journalism,	81 **II.**	4 (5)							
Rural Journalism,	82 **III.**	4 (5)							
Agricultural Economics,	51 **III.**	5	**IV.**						
Economics and Sociology,	51 **I.**	5							
Courses to be individually prescribed for remainder of 45 hours.		5							
		45							

SOPHOMORE PREREQUISITES. — All sophomore English; Economics and Sociology 26. II.

SOPHOMORE RECOMMENDATIONS. — French or German 25 (28), 26 (29), 27 (30); Drawing 25. *For agricultural journalism especially:* Animal Husbandry 25, 26, Chemistry 30, Entomology 26, 27.

ADVISED. — French or German at least two years in college; at least two courses in literature; Music; Landscape 75, 78; Chemistry 87; Entomology 90; Microbiology 50; (Veterinary 78); Zoölogy 27; Geology 27; Agricultural Education 50, 53; Rural Sociology 50, 52; other courses in Economics and Sociology, Rural Sociology, Agricultural Economics, History and Government. *Especially for agricultural journalism:* Agronomy 50, 51; Animal Husbandry 51; Dairying 77; Farm Management 75, 76; Poultry 50; Rural Engineering 75, 76; Horticulture 27, 75; Forestry 52; Market Gardening 50; Pomology 50; Mathematics (75), 77; Veterinary 78; other courses in the economics and the sociology departments bearing on rural problems.

AGRICULTURAL ECONOMICS. (Major.)

Professor ALEXANDER E. CANCE, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Agricultural Economics,	50 **I.**	5	**I.**			Agricultural Economics 50,	5	Agricultural Economics 77,	5
Agricultural Economics,	52 **II.**	5				Economic Sociology 51,	5		
Agricultural Economics,	53 **III.**	5							
Agricultural Economics,	78 **III.**	3							
Agricultural Economics,	76 **II.**		**II.**			Agricultural Economics 52,	5	Agricultural Economics 76,	5
or		5				Rural Sociology 51,	3	Rural Sociology 78,	5
Agricultural Economics,	77 **I.**					Economic Sociology 50,	5		
Economic Sociology,	51 **I.**	5							
Economic Sociology,	50 **II.**	5	**III.**			Rural Sociology 52,	3	Farm Management 76,	5
Farm Management,	76 **III.**	5				Agricultural Economics 53,	5	Agricultural Economics 78,	3
Rural Sociology,	51 **II.**								
or		3							
Rural Sociology,	52 **III.**		**IV.**						
Rural Sociology,	78 **II.**	5							
		46							

ADDITIONAL INFORMATION. — The sophomore electives are left to the student to choose.

AGRICULTURAL EDUCATION. (Major.)

Professor WILLIAM R. HART, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.
Agricultural Education, ...	50 **I.**	5
Agricultural Education, ...	51 **II.**	5
Agricultural Education, ...	52 **I.**	
Agricultural Education, ...	52 **II.**	
Agricultural Education, ...	52 **III.**	
Agricultural Education, ...	52 **IV.**	5
Agricultural Education, ...	53 **III.**	5
Agronomy, ...	50 **I.**	5
Agronomy, ...	75 **I.**	5
Botany, ...	50 **I.**	2
Botany, ...	51 **II.**	2
Dairying, ...	77 **I.**	5
Farm Management, ...	75 **II.**	3
Market Gardening, ...	50 **III.**	3
Pomology, ...	50 **I.**	3
Poultry Husbandry, ...	50 **I.**	3
		51

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.			Botany 50, ...	2	Agronomy 75, ...	5
			Agricultural Education 50,	5	Poultry 50, ...	3
			Agronomy 50, ...	5	Dairying 77, ...	5
			Pomology 50, ...	3	Agricultural Education 52,	5
II.			Botany 51, ...	2	Farm Management 75, .	3
					Agricultural Education, 51,	5
					Agricultural Education, 52,	5
III.			Market Gardening 50, .	3	Agricultural Education, 52,	5
			Agricultural Education 53,	5		
IV.					Agricultural Education 52,	5

ADDITIONAL INFORMATION. — The sophomore electives allowed are left to the student to choose.

Substitutions of other technical courses for some of those above mentioned may be made to meet the needs of individual students.

A selection is allowed of Poultry Husbandry 50 and Market Gardening 50, making 6 credits, or Agronomy 75, 5 credits, making the total credits 45 or 46.

Rural Sociology. (Major.)

Professor John Phelan, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Agricultural Economics, Agricultural Economics, Economics and Sociology, Economics and Sociology,	50 **I.** 52 **II.** 51 **II.** 75 **I.**	5 5 5 5	**I.**			Agricultural Economics 50, Rural Sociology 50,	5 3	Rural Sociology 75, Economics and Sociology 75,	3 5
Economic Sociology, Rural Journalism,	76 **III.** 55 **III.**	5 3	**II.**			Rural Sociology 51, Agricultural Economics 52, Agricultural Education 52, Economic Sociology 51,	3 5 5 5	Rural Sociology 77, Rural Sociology 78,	3 5
Rural Sociology, Rural Sociology, Rural Sociology,	50 **I.** 52 **III.** 51 **II.**	3 3 3	**III.**			Rural Journalism 55, Rural Sociology 52,	3 3	Economic Sociology 76,	5
Rural Sociology, Rural Sociology,	77 **II.** 75 **I.**	3 3	**IV.**						
Agricultural Education, or Rural Sociology,	52 **II.** 78 **II.**	5							
		48							

Additional Information. — The sophomore electives allowed are left to the student to choose.

DESCRIPTION OF COURSES.

DESCRIPTION OF COURSES.

DIVISION OF AGRICULTURE.

Professor FOORD.

[Heavy-faced Roman numerals indicate the term in which the course is given. Numbering of courses: 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

AGRICULTURE AND HORTICULTURE. — Freshmen. This course continuing through the year constitutes the required elementary work dealing with the foundations of the subjects of live stock and the crops of the field, orchard and the garden. Several departments collaborate in giving the work; three credits each term are assigned to this course. For a description of the work, and for information as to distribution of credits, see the following: —

Agronomy 1, I., II., III.
Animal Husbandry 1, II.
Poultry Husbandry 1, I.
Horticulture 1, I., II., III.

Agronomy.

Associate Professor BEAUMONT, Assistant Professor JONES, Mr. MERKLE, Mr. PURINGTON, Mr. GORDON.

Required Course.

1. **I.** 2. **II.** 3. **III.** AGRONOMY. — Freshmen. Given as part of the freshman agriculture and horticulture. This course aims, by actual contact with the plants and the plant products, to make the students familiar with the common field, garden and orchard crops of Massachusetts.

1.	2 2-hour laboratory periods.	Credit, 2.
2.	1 2-hour laboratory period.	Credit, 1.
3.	2 2-hour laboratory periods.	Credit, 2.

Assistant Professor JONES and Mr. MERKLE.

Elective Courses.

29. **II.** SOIL FERTILITY. — For unclassified students. A study of soils and their properties, manure, fertilizers and soil amendments. The principles and factors of soil management are considered together with economical and practical means of improving and maintaining soil fertility.

3 class hours. 1 2-hour laboratory period, credit, 4.

Associate Professor BEAUMONT and the DEPARTMENT.

50. **I.** FIELD AND FORAGE CROPS. — For juniors; seniors may elect. History, classification and production of corn and of those grasses, legumes, root and tuber crops suited to New England conditions. Crops of less im-

portance in New England are briefly considered. The work includes lecture, laboratory and field study.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Assistant Professor Jones and the Department.
Prerequisites, Agronomy 27, Botany 3.

51. **III.** Advanced Field Crops. For juniors; seniors may elect. Study of the cereals and other field crops not taken up or only briefly considered in Course 50. General problems of crop production are also considered, and the work is not entirely confined to New England conditions. The laboratory work includes a study of the cereals, the quality of seeds, grains and crop products, crop problems and field work with such crops as are available.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Jones and the Department.
Prerequisite, Agronomy 50.

75. **I.** Advanced Soils. — For seniors; juniors may elect. A field, lecture and laboratory course on soils and their adaptability to different uses. The field work consists of a detailed study of soil textures, natural and spontaneous vegetation and other factors which indicate the fertility and adaptation of the soil; accompanied by a laboratory study of the physical properties of the soils sampled.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Associate Professor Beaumont and Mr. Merkle.
Prerequisite, Agronomy 27.

76. **III.** Drainage and Irrigation. — For seniors; juniors may elect. A field and lecture course on soil improvement by drainage and irrigation, with special reference to problems of this nature as faced by Massachusetts farmers. Given in association with the department of Rural Engineering.
2 class hours. 1 2-hour and 1 4-hour laboratory period, credit, 5.
Associate Professor Beaumont and Mr. Merkle.
Prerequisites, Mathematics 26 and 27, Agronomy 27.

77. **II.** Manures and Fertilizers. — Seniors. An advanced course, giving a general discussion of the different theories which have been held relative to the functions and importance of manures and fertilizers, and leading up to the views at present accepted. Considerable attention is devoted to consideration of the experimental work which has been done, and which is now in progress. The laboratory work consists of a study of fertilizers, fertilizer mixtures, limes and culture work.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Associate Professor Beaumont and Mr. Merkle.
Prerequisite, Agronomy 27.

78. **II.** Breeding of Field Crops. — Seniors. This course deals with the improvement, by selection and breeding, of the crops studied in Courses 50 and 51.
3 class hours.
Assistant Professor Jones.
Prerequisite, Agronomy 51.

Animal Husbandry.

Professor McNutt, Assistant Professor Pontius.

Required Course.

1. **II.** Animal Husbandry. — Freshmen. Given as part of the freshman agriculture and horticulture. This course acquaints the student with the foundations of the live-stock industry. In the lectures the types and market classes of farm animals, and their uses, are considered; in the laboratory period elementary judging practice familiarizes the student with animals of the various types.
1 class hour. 1 2-hour laboratory period, credit, 2.
Professor McNutt.

Elective Courses.

25. **I.** Breeds and Types of Live Stock. — Sophomores. A course covering the origin, history, development and characteristics of the different breeds of horses, cattle, sheep and swine. Textbook, Plumb's "Breeds and Types of Farm Animals."
2 lectures. 1 2-hour laboratory period, credit, 3.
Assistant Professor Pontius.

26. **II.** Breeds and Types of Live Stock. — Sophomores. Continuation of Course 25.
2 lectures. 1 2-hour laboratory period, credit, 3.
Assistant Professor Pontius.

Prerequisite, Animal Husbandry 25.

50. **II.** Live Stock Management. — For juniors; seniors may elect. The work of this course consists of laboratory work by the individual students in the handling of live stock; with horses, such work as halter breaking, harnessing, casting and fitting for show will be done; similarly, the practical handling of cattle, sheep and swine will be fully treated. Special study is given to halter making, splicing, hitches, knots and all rope work.
1 lecture. 2 2-hour laboratory period, credit, 3.
Professor McNutt.

Prerequisites, Animal Husbandry 25 and 26.

51. **III.** Principles of Breeding. — For juniors; seniors may elect. This course is designed to familiarize the student with the problems that are involved in animal improvement; to acquaint him with the facts which are already established; to scrutinize prevailing theories; and to indicate the lines and methods of further work. Some of the subjects studied are: variations, their causes and heritability; DeVrie's theory of mutations; the inheritance of acquired characters; the pure line; Mendelian law; the making of new types; the determination of sex; applications to human heredity. A few periods at the end of the course are devoted especially to the application of principles in live-stock improvement. "Genetics," by Herbert E. Walter. Supplementary reading.
3 class hours. Credit, 3.
Assistant Professor Pontius.

Prerequisite, Zoölogy 25.

52. **III.** Advanced Stock Judging. — For juniors; seniors may elect. This course is designed to equip animal husbandry students in the judging of classes of different types of live stock; to strengthen them in the selection of superior sires; and equip them for stock judging at fairs. Visits will be made to the best herds for the various breeds of stock in the State. Judging teams to represent the college will be selected from this class.

1 2-hour and 1 4-hour laboratory period, credit, 3.
Professor McNutt.

Prerequisite, Animal Husbandry 50.

75. **I.** Feeding and Management. — For seniors; juniors may elect. A study of the principles of animal nutrition; of the composition and qualities of feeding materials. Textbook, Henry's "Feeds and Feeding."

3 class hours. Credit, 3.
Assistant Professor Pontius.

Prerequisite, Chemistry 30 or 51.

76. **II.** Feeding and Management. — For seniors; juniors may elect. A study of the feeding, care and management of dairy cattle from birth to maturity, with especial attention to economic production. Textbook, Henry's "Feeds and Feeding."

3 class hours. Credit, 3.
Assistant Professor Pontius.

Prerequisite, Chemistry 30 or 51.

77. **III.** Feeding and Management. — For seniors; juniors may elect. A continuation of Courses 75 and 76, dealing in a similar manner with horses, sheep, beef cattle and swine.

3 class hours. Credit, 3.
Assistant Professor Pontius.

Prerequisite, Animal Husbandry 75.

78. **II.** Herd and Stud-book Study. — For seniors; juniors may elect. An advanced course in the study of the breeds of live stock, familiarizing the student with the detailed history of the breed, the most productive sires and dams of the various breeds, and the successful lines and methods of breeding.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor McNutt.

Prerequisite, Animal Husbandry 75.

80. **III.** Seminar. — For seniors majoring in animal husbandry only. Advanced study upon questions pertaining to live stock and live-stock production. Each student electing this work will choose some particular line of work in which he is specially interested, and will pursue study in this subject by reading, compilation and research. There will be no regular lecture period, but seminars will be held. A satisfactory report of the results must be presented in a thesis.

1 2-hour laboratory period, credit, 1.
Professor McNutt.

Dairying.

Professor LOCKWOOD, Assistant Professor JAMISON, Mr. VAN HORN, Mr. DRAIN.

Elective Courses.

50. **I.** MILK AND MILK COMPOSITION. — For juniors; seniors may elect. The development of the dairy business in the United States; the composition, secretion and general characteristics of milk; contamination and fermentation; the study of analysis of milk products by use of the Babcock test for fat, tests for acidity and adulteration, and ordinary preservatives; moisture tests for butter; methods for testing herds and developing them to higher efficiency; problems.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor JAMISON and the DEPARTMENT.

51. **III.** BUTTER MAKING. — For juniors; seniors may elect. A study of separators and cream separation; handling milk and cream for butter making; preparation of starters, and ripening cream; churning; markets and their requirements; marketing, scoring and judging butter; management; problems; dairy machinery and care thereof.
2 class hours. 2 3-hour laboratory periods, credit, 5.
Assistant Professor JAMISON and Mr. VAN HORN.
Prerequisite, Dairying 50.

75. **II.** MARKET MILK. — For seniors; juniors may elect. A study of market-milk conditions; extent and development of the business; supply and delivery; food value of milk and its uses as food; milk and its relation to the public health; proper methods for handling milk and cream for direct consumption; certified milk, requirements and production; pasteurizing; sterilizing; standardizing and modifying; milk laws and inspection.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor LOCKWOOD and the DEPARTMENT.
Prerequisite, Dairying 50.

76. **III.** MILK PRODUCTS. — For seniors; juniors may elect. The manufacture of milk products other than butter, including cheddar cheese, soft and fancy cheese, ice cream, condensed milk, casein, milk powder, etc. Laboratories, largely the making of soft and fancy cheese and ice cream.
2 class hours. 2 3-hour laboratory periods, credit, 5.
Mr. DRAIN.
Prerequisite, Dairying 75.

77. **I.** DAIRYING. — For seniors; juniors may elect. A general course designed primarily for students who wish to take only one course in dairying. The work given will cover briefly the composition and secretion of milk, the Babcock fat test, the relation of bacteria to dairy work and principles of creaming; separators; elementary butter making; proper methods of handling milk and cream; and the relation of market milk to the public health.
3 lecture hours. 2 2-hour laboratory periods, credit, 5.
Mr. DRAIN and the DEPARTMENT.

Farm Management.

Professor Foord, Mr. Peacock.

Elective Courses.

75. **II.** Farm Cost Accounting. — For seniors; juniors may elect. A study of farm inventories, single-enterprise accounts, complete farm accounts, and farm records. Special emphasis is given to the interpretation of results and their application in the organization and management of the farm.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Foord and Mr. Peacock.

76. **III.** Farm Management. — For seniors; juniors may elect. The student should have had considerable farm experience before taking this course. Discussion and study of farming as a business; size, diversity and production and their influence on the farmer's labor income; relation of live stock to profits; regions and types of farming; cropping systems; efficient arrangement of fields and buildings; efficient use of labor, horses and machinery; marketing; methods of renting land; ways of starting farming; proper diversion of capital invested in land, buildings, stock, machinery and supplies; choosing and buying a farm, and organization and management of specific farms in the State.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor Foord and Mr. Peacock.
Prerequisites, Agronomy 50, Animal Husbandry 25 and 26.

Poultry Husbandry.

Professor Graham, Dr. Goodale, Assistant Professor Payne, Mr. Stewart.

Required Course.

1. **I.** Poultry Husbandry. — Freshmen. Given as part of the freshman agriculture and horticulture. The object of this course is to familiarize the student in a general way with the fundamental principles of poultry husbandry, — types of poultry houses, appliances, feeds and market products.
1 2-hour laboratory period, credit, 1.
Mr. Stewart.

Elective Courses.

50. **I.** Elements of Poultry Culture. — For juniors; seniors may elect. This course consists of a comprehensive study of opportunities in poultry culture, poultry-house construction, poultry-house equipment, feeds and feeding, winter-egg production, types and breeds of poultry.
3 class hours. Credit, 3.
Professor Graham, Assistant Professor Payne and Mr. Stewart.

51. **I.** Poultry Practice Work. — For juniors; seniors may elect. This is a practical laboratory course providing a study of external parasites, insecticides, poultry carpentry, caponizing, killing and picking; dressing and packing poultry.
2 2-hour laboratory periods, credit, 2.
Assistant Professor Payne.
Prerequisite, must be accompanied by Poultry 50.

52. **II.** Elements of Poultry Culture. — For juniors; seniors may elect. This course treats the subjects of incubation, brooding, care of growing stock, breeding for egg-production and diseases of poultry.
3 class hours. Credit, 3.
Assistant Professor Payne and Mr. Stewart.
Prerequisite, Poultry 50.

53. **III.** Incubation and Brooding. — For juniors; seniors may elect. In this course students are required to set up and operate incubators and brooders, make a systematic study of the development of the chick in the egg and the care of sitting hens. Laboratory time by arrangement.
1 class hour. 4 2-hour laboratory periods, credit, 5.
Assistant Professor Payne.
Prerequisite, Poultry 52.

54. **III.** Pen Management. — For juniors; seniors may elect. This is a practical laboratory course. Students are required to care for a pen of fowls, keeping accurate records of eggs produced, food consumed, weather conditions, health of fowls and profit and loss.
1 2-hour laboratory period, credit, 1.
Assistant Professor Payne and Mr. Cockell.
Prerequisite, Poultry 50.

55. **I., II. and III.** Investigational Work. — Seniors. This course is designed especially for students who are planning to do experiment station work. Students will be assigned specific problems to work out experimentally, or they may be required to assist in carrying on such work.
1 to 5 2-hour laboratory periods, credits, 1 to 5.
Dr. Goodale.

75. **II.** Poultry Management. — Seniors. A detailed study of large poultry farms and their equipment, such as bone cutters, feed cutters, cramming machines, etc.; the laying out and planning of poultry buildings of all kinds; mating of fowls. Attention to poultry diseases and investigation work carried on by experiment station is prominent. A few good poultry plants will be visited by the class for practical demonstrations.
5 class hours. Credit, 5.
Professor Graham.
Prerequisites, Poultry 53, 54, 76 and 77.

76. **I.** Advanced Poultry Judging. — Seniors. This course includes a study of the origin and history of breeds and varieties, poultry organizations and poultry shows. The laboratory work covers score card and comparative judging of exhibition and utility poultry; conditioning show birds, and applying the latest methods of selecting high and low producing hens. A few of the best Connecticut Valley poultry shows will be visited by the class. The American Standard of Perfection will be used as a text.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Mr. Stewart.
Prerequisite, Poultry 53.

77. **I.** Market Poultry and Poultry Products. — Seniors. This course includes the study of market classifications of poultry, eggs and feathers,

the requirements of different markets, methods of marketing, advantages and disadvantages of cold storage of poultry and eggs. Students will be required to fatten several lots of chickens by different methods and rations. Accurate data must be kept showing the gain in weight and quality, also the cost of feed, labor, etc., and the profit and loss. Preserving eggs, judging and scoring of market poultry, both alive and dressed, and market eggs will be an important feature of this course.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Assistant Professor PAYNE.

Prerequisites, Poultry 50, 51 and 52.

Rural Engineering.

Professor GUNNESS.

Elective Courses.

25. **I.** CARPENTRY. — For sophomores; juniors and seniors may elect. Practice in the use of tools by exercises in bench work, repair of farm equipment and farm building construction.
2 2-hour laboratory periods, credit, 2.
RURAL ENGINEERING DEPARTMENT.

26. **II.** REPAIR OF FARM EQUIPMENT. — For sophomores; juniors and seniors may elect. Exercises in forge work, pipe fitting, soldering. Practice in the use of machinists' tools, such as file, cold chisel, drill press, taps and dies.
2 2-hour laboratory periods, credit, 2.
RURAL ENGINEERING DEPARTMENT.

75. **I.** FARM STRUCTURES. — For seniors; juniors may elect. Study of the strength, durability and cost of building materials; water supply; lighting and heating systems for the farm; drawing plans, writing specifications and estimating the cost of buildings; concrete construction as applied to foundations, silos, tanks, posts, floors and walks.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor GUNNESS.

76. **I.** FARM MECHANICS. — For seniors; juniors may elect. A general study of the farm equipment; farm buildings, their location, plan and arrangement; water supply; sewage disposal; lighting and heating systems; farm power and farm machinery. Course 76 has been planned for the benefit of those students who want a general course in farm mechanics but cannot spend the time to take the two courses 75 and 78.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor GUNNESS.

77. **II.** POWER MACHINERY. — For seniors; juniors may elect. Steam and gasoline engines, refrigerating machinery, electric motors and dynamos. Practice in pipe fitting, soldering, babbitting and fitting bearings, lacing belts and packing valves. Course 77 is intended primarily for dairy students, but would be valuable to any man who would expect to use engines, pumps or electrical machinery.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Professor GUNNESS.

78. **III.** Farm Machinery. — For seniors; juniors may elect. Study of the care and operation of tillage, seeding, harvesting, pumping and spraying machinery; steam and gas engines. Special attention will be given to the use of power on the small farm. Practice in the adjustment of the various machines, babbitting and fitting bearings, lining shafts and pulleys, lacing belts, and splicing rope.

2 class hours. 3 2-hour laboratory periods, credit, 5.

Professor Gunness.

DIVISION OF HORTICULTURE.

Professor Waugh, Assistant Professor Thompson, Assistant Professor Wheeler.

[The general subject of horticulture divides naturally into subjects of pomology, floriculture, forestry, landscape gardening and market gardening. A number of courses relate to more than one of these subjects, and are therefore grouped here under the general designation of horticulture.]

Required Course.

1. **I.** 2. **II.** 3. **III.** Horticulture. — Freshmen. Given as part of the freshman agriculture and horticulture.

Assistant Professor Wheeler.

Elective Courses (General).

27. **III.** Nursery Practice. — For sophomores; juniors and seniors may elect. This course treats of the fundamental methods of plant propagations by seeds, cuttings, budding, grafting, etc. Lectures and practicums.

2 class hours. 1 2-hour laboratory period, credit, 3.

Assistant Professor Thompson.

50. **I.** Plant Materials. — For juniors; seniors may elect. This course aims to make the student familiar with the character of the trees, shrubs and herbaceous perennials used in ornamental work, and with the methods of propagating them.

3 class hours. 2 2-hour laboratory periods, credit, 5.

Assistant Professor Thompson.

Prerequisite, Horticulture 27.

51. **III.** Plant Materials. — For juniors; seniors may elect. A continuation of Course 50, taking up the field use of trees, shrubs and herbaceous plants, their native habitats, soils and plant associations, with a view to supplying to students in landscape gardening and floriculture a knowledge of plant species. Frequent practicums and field excursions.

3 class hours. 2 2-hour laboratory periods, credit, 5.

Assistant Professor Thompson.

Prerequisite, Horticulture 50.

75. **I.** Plant Breeding. — For seniors and graduate students. [Not given in 1917–18.] This course is designed to introduce advanced students to the best modern views of variation, heredity and evolution, and to the best methods of studying the phenomena found in these subjects. The principles educed apply to both animal breeding and plant breeding, but the laboratory work (of which there is considerable) is concerned chiefly with plant life. Some practice work in hybridization and selection is undertaken, and students are trained as far as possible in the practical application of those principles which have direct bearing on the breeding of plants and the cultivation of crops.

3 class hours. 2 2-hour laboratory periods, credit, 5.

Prerequisite, open only to students well prepared in agricultural or horticultural subjects.

Floriculture.

Assistant Professor Hecht, Mr. Wildon.

Elective Courses.

50. **I.** Greenhouse Management. — For juniors; seniors may elect. This course is designed to familiarize students with the methods followed in the management of greenhouse crops. The students are instructed in the practical operations of watering, potting, fumigating, ventilating and in the methods of propagation of plants by seed and cuttings. They will also be expected to arrange their hours according to the needs of the work.
2 class hours. 1 4-hour laboratory period, credit, 4.
Assistant Professor Hecht and Mr. Wildon.
Prerequisite, Horticulture 27.

51. **II.** Greenhouse Management. — For juniors; seniors may elect. Continuation of Course 50.
2 class hours. 1 4-hour laboratory period, credit, 4.
Assistant Professor Hecht and Mr. Wildon.
Prerequisite, Floriculture 50.

52. **III.** Greenhouse Management. — For juniors; seniors may elect. A continuation of Courses 50 and 51.
2 class hours. 1 4-hour laboratory period, credit, 4.
Assistant Professor Hecht and Mr. Wildon.
Prerequisite, Floriculture 51.

53. **I.** Greenhouse Construction. — For juniors; seniors may elect. The location, arrangement, construction, cost, heating and ventilating of greenhouse structures; also the drawing of plans and drafting of specifications for commercial houses and private ranges. Such practical work as glazing, the construction of concrete benches and cold frames will be included in this course.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor Hecht and Mr. Wildon.
Prerequisite, should be taken with Floriculture 50.

54. **II.** Greenhouse Construction. — For juniors; seniors may elect. A continuation of Course 53.
2 class hours. 1 2-hour laboratory period.
Assistant Professor Hecht.
Prerequisite, Floriculture 53.

75. **I.** Commercial Floriculture. — Seniors. A detailed study will be made of the methods of culture for greenhouse plants and cut flowers for wholesale and retail markets. The care and marketing of all florists' crops will also be considered. Assigned readings on these topics.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor Hecht.
Prerequisite, Floriculture 52.

76. **III.** Commercial Floriculture. — Seniors. As stated under Course 75.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor Hecht.
Prerequisites, Floriculture 75 and 80.

77. **II.** Conservatory Work and Decorative Plants. — Seniors. A study of the tropical and subtropical foliage and flowering plants used in conservatory work. Their arrangement and care will also be considered. Assigned readings.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor Hecht.
Prerequisite, Floriculture 75.

78. **III.** Garden Flowers and Bedding Plants. — Juniors and seniors. This course aims to make the student familiar with those annuals, herbaceous perennials, bulbs and bedding plants used in landscape work. Their propagation, culture and uses will be considered. Assigned readings and field trips.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor Hecht and Mr. Wildon.

79. **III.** Seminar. — For seniors majoring in floriculture only. Advanced study of subjects pertaining to commercial floriculture or private garden work. All students electing this work will be assigned a specific problem, and will pursue study in these problems by reading and research. No regular lectures will be given, but seminars will be conducted each week. A satisfactory report of the results must be presented.
2 to 6 laboratory hours. Not to exceed 3 credits.
Assistant Professor Hecht.

80. **II.** Commercial Floriculture. — Seniors. As stated under Course 75.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor Hecht and Mr. Wildon.
Prerequisite, Floriculture 75.

Forestry.

Professor Clark.

Elective Courses.

50. **I.** Dendrology. — For juniors; seniors may elect. During the first part of the term frequent field trips will be made to identify and study the habits of our native forest trees. Later, the classification, range, distribution, forest habits, quality, uses and identification of wood of the commercial timber trees of the United States will be studied. Lectures, recitations, laboratories or field work at option of instructor.
3 2-hour laboratory periods, credit, 3.
Professor Clark.

51. **II.** Wood Technology. — For juniors; seniors may elect. A study of the commercial woods found in the lumber markets, methods of identifica-

tion, uses, strength values, technical qualities, decay and methods of preservation.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Clark.

52. **III.** Principles of Forestry. — For juniors; seniors may elect. A lecture course for the purpose of giving the students a general view of the whole field of forestry and what forestry attempts to accomplish and has accomplished. Not required of students who propose to major in forestry.
2 class hours. Credit, 2.
Professor Clark.

53. **III.** Silviculture. — For juniors; seniors may elect. Factors influencing forest growth; forest types; silvicultural systems; care and protection of forests; forest description; forest nursery practice and forest planting.
1 class hour. 1 4-hour laboratory period, credit, 3.
Professor Clark.

Prerequisite, Forestry 50.

54. **IV.** Arboriculture. — For juniors; seniors may elect. A course dealing with problems of shade tree propagation, protection and repair; the choice and grouping of species; shade tree laws. Assigned readings.
120 hours' field work, credit, 5.
Professor Clark.

75. **I.** Forest Mensuration. — For seniors; juniors may elect. Methods of determining the volume of trees, logs and entire forests. Methods of computing volume tables, tree and forest growth and yield tables. Timber estimating.
3 class hours. 72 hours' field work, credit, 5.
Professor Clark.

78. **III.** Seminar — Report. — Seniors. This may involve research, laboratory or field work in the investigation of some subject, together with a review of the literature relating to it and an original written report evidencing the results. Subject to be chosen in conference with Professor Clark.
6 laboratory hours, credit, 3.
Professor Clark.

Landscape Gardening.

Professor Waugh, Assistant Professor Harrison.

Elective Courses.

50. **I.** Elements of Landscape Gardening. — Juniors. Reconnoissance surveys and mapping, with special reference to the methods used in landscape gardening; detailed study of selected designs of leading landscape gardeners; grade design, road design and field work. Must be followed by Course 51.
2 2-hour laboratory periods; 2 3-hour laboratory periods, credit, 5.
Professor Waugh.

Prerequisites, Mathematics 25 and 26, Drawing 25, 26 and 27, Horticulture 27.

51. **II.** Elements of Landscape Gardening. — Juniors. As stated under Course 50.

3 3-hour laboratory periods, credit, 4.
Assistant Professor Harrison.

Prerequisite, Landscape Gardening 50.

52. **III.** General Design. — Juniors. Field notes; examination of completed works and those under construction; design of architectural details, planting plans, gardens, parks and private grounds; written reports on individual problems. Must be followed by Course 53.

2 2-hour laboratory periods; 2 3-hour laboratory periods, credit, 5.
Assistant Professor Harrison.

Prerequisites, Landscape Gardening 50 and 51, and either plant materials (Horticulture 50 and 51) or advanced mathematics.

53. **IV.** (Summer.) General Design. — Juniors. As stated under Course 52.

120 laboratory hours, credit, 5.
Assistant Professor Harrison.

Prerequisite, Landscape Gardening 52.

75. **I.** Theory of Landscape Art. — For seniors and graduates. The general theory and applications of landscape study, including a brief history of the art.

3 class hours. Credit, 3.
Professor Waugh.

76. **II.** Civic Art. — Seniors. The principles and applications of modern civic art, including city planning, city improvement, village improvement and rural improvement, with special emphasis upon country planning. Must be followed by Course 77.

3 3-hour laboratory periods, credit, 4.
Professor Waugh.

Prerequisite, Landscape Gardening 53.

77. **III.** Civic Art. — Seniors. As stated under Course 76.

3 3-hour laboratory periods, credit, 4.
Professor Waugh.

Prerequisite, Landscape Gardening 76.

78. **III.** Architecture. — Alternating with Course 79; given in 1916–17. Juniors and seniors. The history of architectural development, the different historic types, with special reference to the underlying principles of construction and design and their relations to landscape design. Illustrated lectures, conferences, practice in designing.

3 class hours. Credit, 3.
Assistant Professor Harrison.

79. **III.** Construction and Maintenance. — Alternating with Course 78; given in 1917–18. Juniors and seniors. Detailed instruction in methods

of construction and planting in carrying out plans, in organization, reporting, accounting, estimating, etc.; maintenance work in parks and on estates, its organization, management, cost, etc.
3 class hours. Credit, 3.
Assistant Professor HARRISON.

Market Gardening.

Professor TOMPSON, Assistant Professor THOMSON.

Elective Courses.

50. **III.** ELEMENTS OF MARKET GARDENING. — Juniors; seniors may elect. A study of the business of commercial vegetable growing to acquaint the student with the fundamental considerations of the business and a knowledge of the market-garden crops. The study of the crops will consist of classroom, laboratory and field work, dealing with propagation, cultivation and marketing. Text and reference books.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor THOMSON.

75. **I.** ELEMENTS OF MARKET GARDENING. — Seniors. A continuation of Market Gardening 50. A systematic study of types, varieties and strains of the leading vegetable crops, as well as a study of the problems of farm planning, irrigation, crop rotation, spraying, storage and methods of marketing and seed production. Text and reference books. Occasional seminars. Laboratory and field work.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor THOMSON.
Prerequisite, Market Gardening 50.

76. **II.** GREENHOUSE VEGETABLE GROWING. — Seniors. A study of the production of vegetables under glass as a business, briefly considering economic reasons for its development, progress in methods and management and the present status of the industry. A study of vegetable-forcing house construction, heating and greenhouse management, as applied to the leading greenhouse crops, lettuce, cucumbers and tomatoes, with proportionate time given to the crops of lesser importance. Text and reference books and periodicals. Greenhouse work in actual production and management is a part of this course, and the student must so arrange that he can give it adequate attention. Considerable seminar work.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor THOMSON.
Prerequisite, Market Gardening 75.

Pomology.

Professor SEARS, Associate Professor CHENOWETH, Mr. FAGAN.

Elective Courses.

50. **I.** PRACTICAL POMOLOGY. — For juniors; seniors may elect. A study of the general principles of the growing of fruits, dealing with such questions as selection of site, soils, windbreaks, laying out plantations, choice of nursery

stock, pruning, culture of orchards, orchard fertilizers, cropping orchards, etc. Lectures, supplemented with text and reference books; field and laboratory exercises.

2 class hours. 1 2-hour laboratory period, credit, 3.

Professor SEARS.

Prerequisite, Horticulture 27.

51. **II.** PRACTICAL POMOLOGY. — For juniors; seniors may elect. As stated under Course 50.

2 class hours. 1 2-hour laboratory period, credit, 3.

Professor SEARS.

Prerequisite, Pomology 50.

52. **III.** PRACTICAL POMOLOGY. — For juniors; seniors may elect. As stated under Course 50.

2 class hours. 1 2-hour laboratory period, credit, 3.

Professor SEARS.

Prerequisite, Pomology 51.

53. **IV.** (Summer.) SMALL FRUITS. — For juniors; seniors may elect. The growing, harvesting, marketing and storing of small fruits, including currants, gooseberries and grapes, together with thinning, spraying, picking and marketing of tree fruits at the college orchards and in private commercial orchards.

120 laboratory hours, credit, 5.

75. **I.** SYSTEMATIC POMOLOGY. — Seniors. A study of the varieties of the different fruits and of nomenclature, with critical descriptions; special reference being given to relationships and classification. Lectures, laboratory and field exercises.

1 class hour. 2 2-hour laboratory periods, credit, 3.

Prerequisite, Pomology 52.

76. **II.** SYSTEMATIC POMOLOGY. — Seniors. As stated under Course 75.

1 class hour. 2 2-hour laboratory periods, credit, 3.

Prerequisite, Pomology 75.

77. **I.** COMMERCIAL POMOLOGY. — Seniors only, majoring in pomology. The picking, handling, storing and marketing of fruits, including a discussion of storage houses, fruit packages, methods of grading and packing, manufacturing, etc. Especial emphasis is placed upon laboratory and field work, where the student is given actual practice in the picking and packing of all the principal fruits, together with the manufacture of by-products.

1 class hour. 2 2-hour laboratory periods, credit, 3.

Associate Professor CHENOWETH.

Prerequisite, Pomology 52.

78. **III.** Spraying. — Seniors. A study of (*a*) spraying materials, their composition, manufacture and preparation for use; the desirable and objectionable qualities of each material, formulas used, cost, tests of purity. (*b*) Spraying machinery, including all the principal types of pumps, nozzles, hose and vehicles; their structure and care. (*c*) Orchard methods in the application of the various materials used, with the important considerations for spraying each fruit and for combating each orchard pest. This course is designed especially to familiarize the student with the practical details of actual spraying work in the orchard. Spray materials are prepared, spraying apparatus is examined and tested, old pumps are overhauled and repaired, and the actual spraying is done in the college orchards and small-fruit plantations.

1 class hour. 2 2-hour laboratory periods, credit, 3.

Professor Sears.

Prerequisite, Pomology 52.

79. **III.** General Pomology. — For seniors; juniors may elect. This course is planned to meet the needs of those students who cannot devote more than one term to the subject but who want a general knowledge of fruit growing. The work will consist of lectures and laboratory exercises on such topics as choosing the locations, kinds and varieties of fruits to grow, securing and setting the plants, care and cultivation, pruning, spraying, pests, harvesting and storing.

2 class hours. 1 2-hour laboratory period, credit, 3.

80. **I.** Seminar. — For seniors majoring in pomology. Advanced study of problems relating to the business of fruit growing. Each student will be assigned a major and a minor problem in lines of work in which he is particularly interested. He will pursue his studies both by reading and research, and the materials obtained will be worked into theses which will be presented to the seminar for discussion. Reports on minor problems will be taken up first. No lectures will be given, but seminar meetings will be held for one period each week.

Credit, 1.

Professor Sears and Associate Professor Chenoweth.

81. **II.** Seminar. — For seniors majoring in pomology. A continuation of Course 80. One seminar meeting each week.

Credit, 1.

Professor Sears and Associate Professor Chenoweth.

82. **III.** Seminar. — For seniors majoring in pomology. A continuation of Course 81. One seminar meeting each week.

Credit, 1.

Professor Sears and Associate Professor Chenoweth.

Drawing.

Mr. Pauley.

Elective Courses.

25. **I.** Free-hand Drawing. — For sophomores; juniors and seniors may elect. Lettering; free-hand perspective; sketching from type models, leaves, flowers and trees, houses, etc.; laying flat and graded washes in water colors; water-color rendering of leaves, flowers and trees; conventional coloring and map rendering in water colors; conventional signs and mapping in ink.

3 2-hour laboratory periods, credit, 3.
Mr. Pauley.

26. **II.** Mechanical Drawing. — For sophomores; juniors and seniors may elect. Inking exercises; geometric problems; projection; intersections, isometric; shades and shadows; parallel; angular and oblique perspective; perspective drawing of buildings. Students should have preparation in plane and solid geometry.

3 2-hour laboratory periods, credit, 3.
Mr. Pauley.

27. **III.** Mechanical Drawing. — For sophomores; juniors and seniors may elect. As stated under Course 26.

3 2-hour laboratory periods, credit, 3.
Mr. Pauley.

Prerequisite, Drawing 26.

DIVISION OF SCIENCE.

Botany.

Professor Osmun, Associate Professor Anderson, Assistant Professor Clark, Mr. McLaughlin, Mr. White.

[Heavy-faced type indicates the term in which the course is given. Numbering of courses: 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

Required Courses.

3. **III.** Morphology and Taxonomy of the Higher Plants (Phanerogamia). — Freshmen. Seeds and seedlings; types of leaves, stems, roots and flowers. Determination and naming of plants, using Gray's "New Manual of Botany." An herbarium of 75 species of plants is required of each student.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Osmun, Mr. McLaughlin and Mr. White.

25. **I.** Anatomy, Physiology and Ecology of the Higher Plants. — Sophomores. Structure, functions, metabolism and environmental relations of seed plants.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Osmun, Mr. McLaughlin and Mr. White.
Prerequisite, Botany 3.

Elective Courses.

26. **II.** Morphology and Taxonomy of the Lower Plants (Crytogamia). — Sophomores. Systematic study of typical forms of bacteria, algae, fungi, lichens, mosses, ferns. (Courses 3, 25 and 26 constitute a general elementary course in botany, and are prerequisites of all subsequent work taken in the Department of Botany.)

1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Osmun, Mr. McLaughlin and Mr. White.
Prerequisite, Botany 25.

50. **I.** Diseases of Crops. — For juniors; seniors may elect. Laboratory and recitations devoted to diseases of the special crops related to the student's major. Arranged in sections for students specializing in (1) agronomy or market gardening; (2) floriculture or landscape gardening; (3) pomology; (4) general; (5) forestry. Students may take the laboratory work in one, two or three sections. The laboratory work for students in entomology is general, and includes the more important diseases studied in the other sections. The class is not sectioned for lectures, which are general.

1 class hour. 1, 2 or 3 2-hour laboratory periods, credits, 2, 3 or 4.
Associate Professor Anderson and Mr. McLaughlin.
Prerequisite, Botany 26.

51. **II.** Diseases of Crops. — For juniors; seniors may elect. As stated under Course 50.

1 class hour. 1, 2 or 3 2-hour laboratory periods, credits, 2, 3 or 4.
Associate Professor Anderson and Mr. McLaughlin.
Prerequisite, Botany 50.

52. **I.** Systematic Mycology. — For juniors; seniors may elect. Morphology and development of typical species representing the orders and families of fungi; practice in identification, collection and preservation of fungi; study of systems of classification; collateral reading. A prerequisite of the senior course in plant pathology, but open to all.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Anderson.
Prerequisite, Botany 26.

53. **II.** Systematic Mycology. — For juniors; seniors may elect. As stated under Course 52.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Anderson.
Prerequisite, Botany 52.

54. **III.** Systematic Mycology. — For juniors; seniors may elect. As stated under Course 52.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Anderson.
Prerequisite, Botany 53.

55. **I.** Plant Histology. — For juniors; seniors may elect. Comparative study of the tissues of plants; training in histological methods, including the use of precision microtomes, methods of killing, fixing, sectioning, staining and mounting; collateral reading and conferences. This course offers valuable training in preparation for further work in botany.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Osmun and Mr. McLaughlin.
Prerequisite, Botany 26.

56. **II.** Plant Histology. — For juniors; seniors may elect. As stated under Course 55.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Osmun and Mr. McLaughlin.
Prerequisite, Botany 55.

75. **I.** Plant Pathology. — Seniors. Comprehensive study of diseases of plants; training in laboratory methods and technique, including culture work and artificial inoculation of hosts; miscellaneous diagnosis; study of literature and representative life histories of pathogens. Prepares for civil service, experiment station and college work.
1 class hour. 4 2-hour laboratory periods, credit, 5.
Professor Osmun and Associate Professor Anderson.
Prerequisite, Botany 54.

76. **II.** Plant Pathology. — Seniors. As stated under Course 75.
1 class hour. 4 2-hour laboratory periods, credit, 5.
Professor Osmun and Associate Professor Anderson.
Prerequisite, Botany 75.

77. **III.** Plant Pathology. — Seniors. As stated under Course 75.
1 class hour. 4 2-hour laboratory periods, credit, 5.
Professor Osmun and Associate Professor Anderson.
Prerequisite, Botany 76.

78. **I.** Plant Physiology. — Seniors. A general course dealing with such topics as absorption, nutrition, growth and movements of plants; training in laboratory methods and the use of apparatus; collateral reading.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Assistant Professor Clark.
Prerequisites, Botany 26 and Chemistry 51.

79. **II.** Plant Physiology. — Seniors. As stated under Course 78.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Assistant Professor Clark.
Prerequisite, Botany 78.

80. **III.** Plant Physiology. — Seniors. As stated under Course 78.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Assistant Professor Clark.
Prerequisite, Botany 79.

82. **II.** Cytology and Embryology. — Seniors. Morphology and physiology of the cell; cell-division; embryonal development.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Mr. McLaughlin.
Prerequisites, Botany 26 and 55.

83. **III.** Cytology and Embryology. — Seniors. As stated under Course 82.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Mr. McLaughlin.
Prerequisite, Botany 82.

86. **I.** Seminar. — For seniors and graduate students. Presentation and discussion of important current botanical papers. A major requirement.
1 class hour. Credit, 1.
The Department.

87. **II.** Seminar. — For seniors and graduate students. As stated under Course 86.
1 class hour. Credit, 1.
The Department.

88. **III.** Seminar. — For seniors and graduate students. As stated under Course 86.
1 class hour or 2 laboratory hours. Credit, 1.
The Department.

General and Agricultural Chemistry.

Professor Lindsey, Professor Wellington, Professor Chamberlain, Professor Peters, Professor Anderson,[1] Mr. Serex, Mr. MacNeil.

[The course in chemistry aims to teach accurate observation, logical thinking and systematic and constant industry. It likewise aims to give those students following the several agricultural occupations, or who are preparing themselves for work as teachers and investigators in the sciences, a knowledge of the subject sufficient to enable them to apply it in their various lines of work. Students taking all of the undergraduate courses and intending to follow chemistry as a vocation are prepared for positions as instructors in high schools and colleges, in the agricultural experiment stations, the United States Department of Agriculture, as well as in fertilizer, cattle food, sugar and dairy industries. Students are encouraged to take especially graduate work leading to the degree of Master of Science, and to thus prepare themselves for advanced positions as teachers in the agricultural colleges, as research chemists, and likewise for the more responsible positions connected with the different agricultural industries of the country. A fuller knowledge of the course of instruction will be found by consulting the following outline.]

Required Courses.

1. **I.** General Chemistry. — Freshmen. An introduction to the fundamental chemical laws, together with a study of the common acid-forming elements and their compounds. Textbook, Kahlenberg's "Outlines of Chemistry." This course is for those students who do not present chemistry for entrance, and who begin the subject in college.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Peters, Mr. Serex and Mr. Julian.

2. **II.** General Chemistry. — Freshmen. A continuation of Course 1. A study of metals and their compounds. The laboratory work is the same as described under Course 4.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Peters and Assistants.

3. **III.** Inorganic Agricultural Chemistry. — Freshmen. As stated under Course 5 **II.**
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Peters and Assistants.

4. **I.** Advanced General Chemistry. — Freshmen. A review of the fundamental chemical laws, together with the common acid and base-forming elements and their compounds. Textbook, Kahlenberg's "Outlines of Chemistry." The laboratory work takes the synthetic form. Substances of agricultural importance are prepared in quantity and studied in detail by the student. These include ammonium sulfate, superphosphate, muriate and sulfate of potash, arsenate of lead, Paris green, Bordeaux mixture, lime-sulfur and emulsions.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Peters and Assistants.

Prerequisite, Entrance Chemistry.

5. **II.** Inorganic Agricultural Chemistry. — Freshmen. A study of the chemical composition, properties and reactions of soils, fertilizers, fungi-

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[1] On leave 1917–19.

cides and insecticides. The laboratory work is divided into three parts, as follows: (*a*) qualitative examination of soil, plant ash and superphosphate; (*b*) approximate quantitative determination of moisture, ash, carbonic acid, phosphoric acid, potash, etc.; (*c*) special work on retention of salts by soil, leaching of lime from the soil by carbonated water, etc.

2 class hours. 1 2-hour laboratory period, credit, 3.
Professor CHAMBERLAIN and Assistants.

6. **III.** ORGANIC AGRICULTURAL CHEMISTRY. — Freshmen. The course embraces the study of the most important groups of organic compounds of plants and animals, the composition of plants, the chemistry of plant growth, plants as food and as industrial material, the composition of animals, the chemistry of digestion, also the study of some of the products related to plants and animals, such as milk, butter, cheese, sugar and alcohol. The treatment of the subject will be general, avoiding (so far as possible) complicated chemical facts and relationships, and endeavoring simply to make the student acquainted with the general chemistry of plants and animals and agricultural processes and products.

2 class hours. 1 2-hour laboratory period, credit, 3.
Professor CHAMBERLAIN and Assistants.

Elective Courses.

7. **I.** ELEMENTARY AGRICULTURAL CHEMISTRY. — Unclassified. This is a special course for unclassified students endeavoring to give in one term the essential facts and ideas of general chemistry and the chemistry of soils and fertilizers so that the student may be able to take up similar special courses in agronomy. The course will consist of a brief study of important elements and compounds, followed by a special study of the chemistry of soils and fertilizers. Textbook, Tottingham & Ince, "Chemistry of the Farm and Home." This will be supplemented by laboratory notes.

4 class hours. 1 2-hour laboratory period, credit, 5.
Professor CHAMBERLAIN.

25. **I.** QUALITATIVE ANALYSIS. — *Basic.* — Sophomores. A course in the systematic analysis of metallic salts, presented from the ionic viewpoint. The student studies closely the tests used in the separation and identification of the metals; he then applies these tests to unknown mixtures. Text, Medicus' "Qualitative Analysis," with Böttger's "Qualitative Analysis" and Treadwell-Hall's "Qualitative Analysis" for reference. This course should be taken, particularly, by all intending to follow chemistry as a vocation.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Mr. SEREX.

Prerequisite, Chemistry 3 or 6.

26. **II.** QUALITATIVE ANALYSIS. — *Acidic.* — Sophomores. A continuation of Course 25.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Mr. SEREX.

27. **III.** QUANTITATIVE ANALYSIS. — For sophomores; juniors and seniors may elect. Instruction in this course includes the gravimetric and volu-

metric determinations of some of the commoner metals and non-metals. Talbot's "Quantitative Chemical Analysis" is used as a text.
1 class hour. 2 4-hour laboratory periods, credit, 5.
Professor WELLINGTON and Professor PETERS.
Prerequisite, Chemistry 25. Course 26 is prerequisite for those majoring in chemistry.

30. **III.** ORGANIC AGRICULTURAL CHEMISTRY. —For sophomores; juniors and seniors may elect. As stated in Course 6.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor CHAMBERLAIN.

51. **I.** ORGANIC CHEMISTRY. — For juniors; seniors may elect. This course consists of a systematic study, both from texts and in the laboratory, of the more important compounds in the entire field of organic chemistry. Especial attention is given to those compounds which are found in agricultural products or are manufactured from them. These include alcohols, acids, esters, fats, carbohydrates and proteins. The work forms a foundation for courses in physiological chemistry and agricultural analysis, and is especially planned for those majoring in chemistry or the other sciences. Those electing Course 51 are expected to elect Course 52.
5 class hours. 2 3-hour laboratory periods, credit, 8.
Professor CHAMBERLAIN.
Prerequisites, Chemistry 3 or 6, and Chemistry 27 for those majoring in chemistry.

52. **II.** ORGANIC CHEMISTRY. — For juniors; seniors may elect. As stated under Course 51.
5 class hours. 2 3-hour laboratory periods, credit, 8.
Professor CHAMBERLAIN.

60. **I.** ADVANCED QUANTITATIVE CHEMISTRY. — For juniors; seniors may elect. Advanced work on subjects as stated under Course 27.
1 class hour. 1 4-hour laboratory period, credit, 3.
Professor WELLINGTON and Professor PETERS.
Prerequisite, Chemistry 27.

61. **II.** INSECTICIDE ANALYSIS. — For juniors; seniors may elect. A study of methods for the analysis of insecticides.
1 class hour. 1 4-hour laboratory period, credit, 3.
Professor WELLINGTON and Professor PETERS.
Prerequisite, Chemistry 27.

62. **III.** SOIL AND FERTILIZER ANALYSES. — For juniors; seniors may elect. A study of methods for analyses of soils and fertilizers.
1 class hour. 2 4-hour laboratory periods, credit, 5.
Professor WELLINGTON and Professor PETERS.
Prerequisite, Chemistry 27.

65. **III.** Physical Chemistry. — For juniors; seniors may elect. A résumé of general chemistry from the viewpoint of physical chemistry, and the application of physical chemistry to agricultural chemistry.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Mr. Serex.

Prerequisite, Chemistry 27.

76. **I.** Milk and Butter Analysis. — For seniors; juniors may elect. A study of chemical methods of analysis of milk and butter.
1 class hour. 2 4-hour laboratory periods, credit, 5.
Professor Peters.

Prerequisite, Chemistry 27.

77. **II.** Cattle Feed, Water and Miscellaneous Analysis. — For seniors; juniors may elect. A study of methods of analysis of cattle feeds and water, with interpretations. Other materials may be analyzed.
1 class hour. 1 4-hour laboratory period, credit, 3.
Professor Peters.

Prerequisite, Chemistry 27.

80. **I.** Physiological Chemistry. — Seniors. This course is intended to be supplementary to Courses 51 and 52. To those who expect to take up scientific work in microbiology, botany, agronomy, animal husbandry, etc., and who have had Courses 51 and 52, it will give acquaintance with the chemistry of the physiological processes in plants and animals, by means of which some of the important organic compounds studied in Courses 51 and 52 are built up in the living organism or are used as food by it. In the lectures the study of food and nutrition as related to both human and domestic animals is the principal subject. In the laboratory experimental studies are made of the animal body and the processes and products of digestion, secretion and excretion.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor Chamberlain.

87. **III.** History of Chemistry. — Seniors. An exposition of the development of chemical knowledge from the earliest times to the present. Although the entire history will be included, the larger portion of it will receive only brief mention in order that the questions of vital interest in modern life and industry may be studied at greater length. Particular attention will be given to the questions of plant and animal industry. Chemists are strongly advised to take this course.
3 class hours. Credit, 3.
Professor Wellington.

90. **II.** Special Work in Agricultural Chemical Analysis. — Seniors. The student is given a problem to solve either in analytical chemistry or related to the agricultural industries. This is to acquaint him with the methods used in research and with the literature, and show him how to handle problems in this field of chemistry when occasion arises.
6 or 10 laboratory hours, credit, 3 or 5.
Professor Peters.

91. **III.** Special Work in Agricultural Chemical Analysis. — Seniors. As stated in Course 90.

10 laboratory hours, credit, 5.
Professor Peters.

Prerequisite, Chemistry 90.

92. **II.** Special Work in Physiological and Organic Agricultural Chemistry. — Seniors. In this course, as in Courses 90 to 95, the student will be able to give his attention primarily to one line of chemical study. To those whose tastes and interests are in connection with the organic and physiological problems of agricultural chemistry, many subjects of study present themselves, among which may be mentioned: proteins, carbohydrates, fats, organic nitrogenous compounds in fertilizers and soils and their relation to plants, the commercial production of alcohol from agricultural products, digestion and dietary studies, the chemical study of dairy products, etc.

6 or 10 laboratory hours, credit, 3 or 5.
Professor Chamberlain.

Prerequisites, Chemistry 51, 52 and 80.

93. **III.** Special Work in Physiological and Organic Agricultural Chemistry. — Seniors. As stated under Course 92.

10 laboratory hours, credit, 5.
Professor Chamberlain.

Prerequisite, Chemistry 92.

94. **II.** Special Work in Physical Chemistry. — Seniors. The field of agricultural chemistry offers many problems that have been attacked through the methods of physical chemistry; such, for example, are the hydrolysis of salts and of minerals and the absorption of salts and fertilizers by soils. Each student will select one line of work and follow it through the course, repeating some of the original work.

6 or 10 laboratory hours, credit, 3 or 5.
Mr. Serex.

Prerequisite, Chemistry 65.

95. **III.** Special Work in Physical Chemistry. — Seniors. As stated under Course 94.

10 laboratory hours, credit, 5.
Mr. Serex.

Prerequisite, Chemistry 94.

Entomology.

Professor Fernald, Professor Crampton, Associate Professor Gates, Dr. Regan.

Elective Courses.

26. **II.** 27. **III.** General and Economic Entomology. — For sophomores; juniors and seniors may elect. This is a general course in the study of insects intended for students in any line of work, and is directly continuous through two terms. It touches upon the structure of insects so far as this is needed for such a course; deals with metamorphosis, classification to the larger groups, and discusses the most important methods and materials used for control. The greater part of the time is devoted to special study of the

most important insect pests, particularly of New England, showing their modes of life, the injuries they cause, and the best methods of control. In this way the most serious pests of fruit trees, ornamental trees and shrubs, market-garden and greenhouse pests, those attacking field crops and those affecting animals and man, are treated. During the winter term and in the spring term until about the first of May instruction is given by lectures and recitations; from about the first of May field work takes the place of the lectures. In this part of the course the students are shown how to find and recognize the work of the various insect pests which may be accessible at that season of the year, and they also make and preserve a collection of insects.
3 class hours. Credit, 3.
Professor FERNALD.

27. **III.** GENERAL AND ECONOMIC ENTOMOLOGY. — As stated under Course 26. **II.**
2 class hours till about May 1; thereafter 2 2-hour field periods. Credit, 2.
Professor FERNALD, Professor CRAMPTON and Dr. REGAN.

50. **I.** PESTS OF SPECIAL CROPS. — For juniors; seniors may elect. For students not majoring in entomology. The laboratory work is largely individual in this term. Accordingly, students majoring in subjects other than entomology, but who desire a more complete knowledge of the insects connected with their own major line of work, can obtain it here. A student majoring in floriculture, for example, will devote his laboratory time to a careful study of the insects injuring floricultural crops, learning how to recognize them and their work in their different stages, and the best methods for their control. Courses of this kind are available on the insects attacking field crops, market-garden crops, tree fruits, small fruits, shade trees and shrubs, flowers, forest trees, the domesticated animals and man. This work may be continued in the winter term also. (See 51, **II.**)

51. **II.** PESTS OF SPECIAL CROPS. — As stated in 50, **I.**

53. **I.** INSECT MORPHOLOGY. — For juniors; seniors may elect. For students majoring in entomology. The lectures of this course treat of the external and internal anatomy of insects, particularly of those characters used in identification, a knowledge of which is needed in the accompanying laboratory work. In the laboratory the external anatomy of the most important groups is studied, followed by the identification of insects of these groups, to show how the characters are made use of in learning the names of insects, and to teach the use of analytical keys.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor CRAMPTON, Professor FERNALD and Dr. REGAN.
Prerequisites, Entomology 26 and 27.

54. **II.** INSECT CLASSIFICATION. — For juniors; seniors may elect. For students majoring in entomology. Systematic identification of insects of various groups. Study of various entomological publications and methods of finding the literature on any insect.
3 2-hour laboratory periods, credit, 3.
Professor FERNALD, Professor CRAMPTON and Dr. REGAN.
Prerequisite, Entomology 53, **I.**

55. **III.** Economic Entomology. — For juniors; seniors may elect. Special studies on the most serious insect pests, their habits, nature of the injuries they cause and methods of control. In the lectures the composition, preparation and methods of application of the more important insecticides, their merits and defects, and studies of insecticide apparatus and other methods of control are treated. A portion of the laboratory time will be used in practical work on the topics taken up in the lectures.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Fernald, Professor Crampton and Dr. Regan.
Prerequisite, Entomology 51.

60. **III.** Beekeeping. — Juniors; seniors may elect. This course comprises a general consideration of the biology of the honey bee and the elements of practical beekeeping. Some topics covered are: life history, general behavior and instincts, structure, products, relations of bees to plants, the honey flora. The course aims particularly to afford first-hand, practical experience with bees, to the end of enabling their proper maintenance for any purpose, horticultural, educational or apicultural. Bee diseases, a thorough understanding of which is fundamental, are emphasized. So far as possible, the work is made individual in constructing materials and apparatus and in the manipulation of bees.
3 lecture hours. 2 2-hour laboratory periods, credit, 5.
Associate Professor Gates.

75. **III.** Forest and Shade-tree Insects. — For seniors; juniors may elect. A study of the insects injurious to forest and shade trees, and of methods for their control, with laboratory and field work on these insects, together with investigation of what is known about them.
1 class hour. 3 2-hour laboratory or field periods, credit, 4.
Dr. Regan.
Prerequisites, Entomology 26 and 27; 53, **I.**, desirable.

76. **I.** Advanced Entomology. — For seniors. During this year studies of scale insects (coccidology), life histories of important pests, the preparation of bibliographies, methods of rearing, photography of insects, methods for experimental work and record keeping, and studies of the early stages of insects will be given. Insects as disease carriers, insect bionomics, and a study of the animals not insects with which entomologists are expected to deal, will also be included in this course.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Professor Fernald, Professor Crampton and Dr. Regan.
Prerequisite, Entomology 55.

77. **II.** Advanced Entomology. — As stated in Course 76, **I.**
3 2-hour laboratory periods, credit, 3.
Professor Fernald, Professor Crampton and Dr. Regan.
Prerequisite, Entomology 76.

78. **III.** Advanced Entomology. — As stated in Course 76, **I.**
1 class hour. 3 2-hour laboratory or field periods, credit, 4.
Professor Fernald, Professor Crampton and Dr. Regan.
Prerequisite, Entomology 77.

80. **III.** Advanced Beekeeping. — Seniors; juniors may elect. This course deals with the advanced and special problems of the beekeeper. Besides considering those difficulties which at present confront the industry, subjects necessarily of limited treatment in the previous course are expanded for the development of particular technique and manipulation. Apiary management, including the principles of queen rearing, is practiced. The course should further qualify for apicultural instruction and inspection service, affording familiarity with the special literature and methods needed in investigation and research. The policy of individual instruction is continued in so far as practicable.
2 lecture hours. 1 2-hour laboratory period, credit, 3.
Associate Professor Gates.

Prerequisite, Course 60.

90. **II.** Evolution. — For juniors; seniors may elect. In order to demonstrate the universal scope and operation of the laws of evolution, the course includes a brief sketch of the probable origin and evolution of matter as viewed in the light of modern physical and chemical research; the evolution of the solar system, leading to the formation of the earth; the changes in the earth, preparatory to the production of life; the physical and chemical basis of life; the probable steps in the formation of living matter, and the theories concerning it; the evolution of living things; the developmental history of man, and of the races of mankind, the evolution of human intelligence, languages, culture, institutions, etc., and man's probable future in the light of his past development. Especial consideration is given to the factors of evolution, the basic principles of heredity, sex-determination, variation and similar topics, with particular reference to their application to human welfare; and the recent contributions in the field of entomology to the advancement of our knowledge of these fundamental principles are briefly reviewed. The lectures are supplemented by collateral reading, and monthly seminars will be held for the purpose of demonstration and discussion by the class.
3 class hours. Credit, 3.
Professor Crampton.

Mathematics and Civil Engineering.

Professor Ostrander, Assistant Professor Duncan, Assistant Professor Machmer,[1]
Mr. Hazeltine.[1]

Required Courses.

1. **I.** Higher Algebra. — Freshmen. A brief review of radicals, quadratic equations, ratio and proportion, and progressions; graphs, binomial theorem, undetermined coefficients, summation of series, variation, continued fractions, determinants, permutations and combinations, logarithms, theory of equations. Fite's "College Algebra."
5 class hours. Credit, 5.
The Department.

2. **II.** Higher Algebra. — As stated under Course 1.
2 class hours. Credit, 2.
The Department.

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[1] Absent on leave.

3. **III.** Solid Geometry. — Freshmen. Theorems and exercises on the properties of straight lines and planes, dihedral and polyhedral angles, prisms, pyramids and regular solids; cylinders, cones and spheres; spherical triangles and the measurement of surfaces and solids. Wentworth and Smith's "Solid Geometry." Required unless accepted for admission.
3 class hours. Credit, 3.
The Department.

5. **II.** Plane Trigonometry (in charge of Department of Physics). — Freshmen. The trigonometric functions as lines and ratios; proofs of the principal formulas, transformations; inverse functions, use of logarithms; the applications to the solution of right and oblique triangles; practical applications. Bowser's "Elements of Plane and Spherical Trigonometry."
3 class hours. Credit, 3.
Professor Hasbrouck and Assistant Professor Robbins.

6. **III.** Mensuration and Computation. — Freshmen. The course includes a review of methods of computation, with special emphasis on short and abbreviated processes, together with methods of checking computations and of forming close approximations; use of slide rule. Also the graph, mensuration of plane and solid figures, weights and measures and elementary mechanism. Numerous practical problems are selected from such subjects as the following: the mathematics of woodworking; rough lumber; general construction; forestry methods in heights of trees; pulleys, belts and speeds; power and its transmission; dairying; agronomy; computation of areas from simple measurements.
2 class hours. Credit, 2.
The Department.

Elective Courses.

26. **II.** Plane Surveying. — For sophomores; juniors and seniors may elect. The elements of the subject, including the adjustment and use of the usual instruments. Textbook and lectures.
2 class hours. Credit, 2.
The Department.

27. **III.** Plane Surveying. — For sophomores; juniors and seniors may elect. As stated under Course 26. Includes field work.
3 2-hour laboratory periods, credit, 3.
The Department.

Prerequisite, Mathematics 26.

50. **I.** Analytic Geometry. — For juniors; seniors may elect. A discussion of the geometry of the line, the circle of conic sections and of the higher plane curves. Fine and Thompson's "Co-ordinate Geometry."
3 class hours. Credit, 3.
The Department.

Prerequisites, Mathematics 1, 2, 3 and 5.

51. **II.** DIFFERENTIAL AND INTEGRAL CALCULUS. — For juniors; seniors may elect. A first course in the subject, with some of the more important applications. Davis's "Differential and Integral Calculus."
5 class hours. Credit, 5.
The DEPARTMENT.

Prerequisites, Mathematics 1, 2, 3 and 5.

52. **III.** INTEGRAL CALCULUS. — For juniors; seniors may elect. A continuation of Course 51.
5 class hours. Credit, 5.
The DEPARTMENT.

Prerequisite, Mathematics 51.

53. **II.** ELEMENTARY STRUCTURES. — For juniors; seniors may elect. An elementary course in roofs and bridges. Textbook and lectures.
3 class hours. 1 2-hour laboratory period, credit, 4.
The DEPARTMENT.

75. **I.** HYDRAULICS AND SANITARY ENGINEERING. — For seniors; juniors may elect. Hydrostatics, theoretical hydraulics, orifices, weirs, pipes, conduits, water supply, hydraulic motors, sewers and sewage treatment. Textbook and lectures.
5 class hours. Credit, 5.
The DEPARTMENT.

76. **I.** MATERIALS OF CONSTRUCTION, FOUNDATIONS AND MASONRY CONSTRUCTION. — For seniors; juniors may elect. Textbook and lectures.
4 class hours. 1 2-hour laboratory period, credit, 5.
The DEPARTMENT.

77. **II.** ROADS AND RAILROADS. — For seniors; juniors may elect. Topographic and higher surveying, highway construction, earthwork, pavements and railroad construction. Textbook and lectures.
3 class hours. Credit, 3.
The DEPARTMENT.

78. **III.** ROADS AND RAILROADS. — For seniors; juniors may elect. As stated under Course 77.
3 2-hour laboratory periods, credit, 3.
The DEPARTMENT.

Prerequisite, Mathematics 77.

79. **I.** APPLIED MECHANICS. — Seniors. A course in applied mechanics, based on the calculus, with problems. Textbooks and lectures.
5 class hours. Credit, 5.
The DEPARTMENT.

Prerequisite, Mathematics 51, 52.

Microbiology.

Professor Marshall, Assistant Professor Itano, Mr. Hood, Mr. Neill.

[Courses 50 and 51 are especially adapted to those who wish a general comprehensive, although elementary, survey of agricultural microbiology.]

Elective Courses.

50. **I. and III.** Introduction and General Microbiology. — For juniors; seniors may elect. A review of the field of microbiology as a whole, with special reference to hygienic microbiology, will constitute this course. It will be taught by means of lectures, demonstrations and textbooks. Although desirable, it will not be required as a prerequisite to all courses that follow, and may be taken along with Course 51.

5 class hours. Credit, 5.

Professor Marshall and Mr. Hood.

51. **I., II. and III.** Morphological, Cultural and Physiological Microbiology. — For juniors; seniors may elect. Types of micro-organisms, technic of handling, methods of culture and functions of micro-organisms are considered. This course is elementary and fundamental to all applied and special microbiological studies, and therefore is made a prerequisite to all courses following. One hour will be scheduled.

10 laboratory hours, credit, 5.

Assistant Professor Itano and Mr. Neill.

52. **III.** Advanced Morphological, Cultural and Physiological Microbiology. — For juniors; seniors may elect. The purpose of this course is to prepare the student for a more intimate knowledge of microbiological agricultural problems. To accomplish this object it is necessary to provide more advanced technic and methods of culture, together with a more extensive knowledge of micro-organisms and their functions. One hour will be scheduled.

10 laboratory hours, credit, 5.

Assistant Professor Itano and Mr. Neill.

Prerequisite, Microbiology 51.

75. **II.** Agricultural Microbiology. — For seniors; juniors may elect. This general comprehensive course is designed to cover in an elementary manner those subjects only which confront the student of general agriculture, — the microbiological features of air, water, sewage, soil, dairy, fermentations, food, vaccines, antisera, microbial plant infections, methods and channels of infections, immunity and susceptibility, microbial infections of man and animals, methods of control or sanitary and hygienic practices. One hour will be scheduled.

10 laboratory hours, credit, 5.

Professor Marshall, Assistant Professor Itano and Mr. Neill or Mr. Hood.

Prerequisite, Microbiology 51.

76. **III.** Agricultural Microbiology. — For seniors; juniors may elect. As stated under Course 75. One hour will be scheduled.

10 laboratory hours, credit, 5.
Professor Marshall, Assistant Professor Itano and Mr. Neill or Mr. Hood.

Prerequisites, Microbiology 52 and 75.

80. **II.** Soil Microbiology. — For seniors; juniors may elect. Such subjects as the number and development of micro-organisms in different soils; the factors which influence their growth, food, reaction, temperature, moisture and aeration; the changes wrought upon inorganic and organic matter in the production of soil fertility, ammonification, nitrification and denitrification; fixation of nitrogen symbiotically and non-symbiotically; methods of soil inoculation receive attention. One hour will be scheduled.

10 laboratory hours, credit, 5.
Assistant Professor Itano.

Prerequisite, Microbiology 51.

81. **I.** Hygienic Microbiology. — For seniors; juniors may elect. An attempt will be made to select for this course certain material which should be the possession of every individual, and which is basic to public hygiene and sanitation, as applied to man and animals. The microbiology of water supplies, food supplies, vaccines, antisera or antitoxins; the channels by which micro-organisms enter the body, the influence of body fluids and tissues upon them, body reactions with micro-organisms (susceptibility and immunity); the micro-organisms of some of the most important infectious diseases, methods of control, including disinfectants and disinfection, antiseptics, antisepsis and asepsis, will be treated. One hour will be scheduled.

10 laboratory hours, credit, 5.
Professor Marshall and Mr. Hood, or Assistant Professor Itano and Mr. Neill.

Prerequisites, Microbiology 50 and 51.

82. **I.** Dairy Microbiology. — For seniors; juniors may elect. Special emphasis will be placed upon milk supplies. The microbial content of milk, its source, its significance, its control; microbial taints and changes in milk; groups or types of organisms found in milk; milk as a carrier of disease-producing organisms; the value of straining, aeration, centrifugal separation, temperature, pasteurization; the abnormal fermentations of milk; bacteriological milk standards and their interpretation; ripening of milk and cream; the bacterial content of butter; a passing survey of the microbiology of cheeses; a study of special dairy products, as ice cream, condensed milk, artificial milk drinks (the products of microbial actions), represents a list of topics considered.

10 laboratory hours, credit, 5.
Professor Marshall and Mr. Hood.

Prerequisites, Microbiology 51, Dairying 51.

83. **I.** Food Microbiology. — For seniors; juniors may elect. A study of food preservation by means of drying, canning, refrigerating and addition

of chemicals will be pursued. Food fermentations, as illustrated by bread, pickles, sauerkraut, ensilage, vinegar, wine, etc., will be examined. Decomposition of foods, as may be seen in meat, oysters, fish, milk, etc., as well as diseased foods, will receive consideration. Contamination of food supplies by means of water, handling, exposure, diseased persons, etc., is of especial significance, and will be demonstrated by laboratory exercises. One hour will be scheduled.

10 laboratory hours, credit, 5.
Professor Marshall and Mr. Hood.

Prerequisite, Microbiology 51.

Physics.

Professor Hasbrouck, Associate Professor Robbins.

[The fundamental and basic importance of the laws and phenomena of physics makes necessary no explanation of the introduction of this subject into the curriculum of an agricultural college. The logical development of the subject emphasizes the importance of physics as a science in itself. Special emphasis is laid, however, on the correlation of the principles studied with the sciences of agriculture, botany, chemistry, zoölogy, thus furnishing an extra tool by use of which the student's work in all the subjects may be more effective.]

Required Courses.

25. **I.** General Physics. — Sophomores. Mechanics of solids and fluids. This course includes statics, with equilibrium of rigid bodies, work, energy and friction; kinetics, considering rectilinear motion and motion in a curved path; harmonic motion; rotation of rigid bodies, including kinematics of rotation; liquids and gases, with properties of fluids at rest and in motion; properties of matter and its internal forces, including elasticity, capillarity, surface tension.

3 class hours. 1 2-hour laboratory period, credit, 4.
Professor Hasbrouck and Associate Professor Robbins.

26. **II.** Electricity and Magnetism. — Sophomores. The work in electricity includes such subject-matter as magnetism, electrostatics, electric currents with their production, chemical, heating and mechanical effects; battery cells, measurement of voltage, current flow and resistance, motors and generators.

2 class hours. 1 2-hour laboratory period, credit, 3.
Associate Professor Robbins.

Elective Courses.

27. **III.** Heat and Light. — For sophomores; juniors and seniors may elect. Thermometry, expansion, colorimetry and specific heat, transmission of heat, changes of state, radiation and absorption. Wave theory of light, optical instruments, analysis of light, color, interference, diffraction, polarization.

4 class hours. 1 2-hour laboratory period, credit, 5.
Professor Hasbrouck and Associate Professor Robbins.

50. **I.** Electricity, Heat and Light. — For juniors; seniors may elect.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Robbins.

Prerequisite, Physics 27.

51. **II.** Electricity, Heat and Light. — For juniors; seniors may elect. Continuation of Course 50.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Robbins.
Prerequisite, Physics 50.

52. **III.** Electricity, Heat and Light. — For juniors; seniors may elect. Continuation of Courses 50 and 51.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Robbins.
Prerequisite, Physics 51.

Veterinary Science.

Professor Paige, Associate Professor Gage.

[The courses in veterinary science have been arranged to meet the needs of students who propose following practical agriculture, and of prospective students of human and comparative medicine.]

Elective Courses.

50. **I.** Veterinary Hygiene and Stable Sanitation. — For juniors; seniors may elect. This course is intended to familiarize the student with the relation of water, food, air, light, ventilation, care of stables, disposal of excrement, individual hygiene, etc., to the prevention of disease in farm animals.
5 class hours. Credit, 5.
Professor Paige.

51. **II.** General Veterinary Pathology. Materia Medica and Therapeutics. — For juniors; seniors may elect. In this course such fundamental and general pathological conditions are studied as inflammation, fever, hypertrophy, atrophy, etc., a knowledge of which is essential in the diagnosis, prevention and treatment of disease. The course in pathology is followed by one in materia medica and therapeutics, dealing with the origin, preparation, pharmacology, pharmacy, administration and therapeutic use of the more common drugs. Poisonous plants and symptoms and treatment of plant poisoning are also considered.
5 class hours. Credit, 5.
Professor Paige.

75. **I.** Comparative (Veterinary) Anatomy. — For seniors; juniors may elect. The anatomy of the horse is studied in detail, and that of other farm animals compared with it where differences exist. This course is essential for those students wishing to elect Course 76.
5 class hours. Credit, 5.
Professor Paige.

76. **II.** Theory and Practice of Veterinary Medicine; General, Special and Operative Surgery. — For seniors; juniors may elect. A course intended to familiarize the student with the various medical and surgical diseases of the different species of farm animals. Particular attention is given to diagnosis and first-aid treatment. The student is taught the technique of simple surgical operations that can with safety be performed by the stock

owner. Lectures, demonstrations and practice. This course should be taken in conjunction with Course 51.
5 class hours. Credit, 5.
Professor PAIGE.
Prerequisite, Veterinary 75.

78. **I.** ESSENTIALS OF GENERAL PATHOLOGY. — For seniors; juniors may elect. This course is planned to introduce the student to some of the essential anatomical, histological and general physiological phenomena essential to the understanding of some of the simple general pathological conditions found in domestic animals. Some of the common methods of diagnosis will be considered in the laboratory. The various chemical and biological reactions and tests will be presented from the standpoint of pure science, showing applications of chemistry and biology. The course will serve to liberally educate and stimulate in the student of agriculture the appreciation of some of the methods used in animal pathology for detecting and controlling some of the more common animal diseases. Lectures, demonstration and laboratory work.
2 3-hour laboratory periods, credit, 3.
Associate Professor GAGE.

79. **II.** ESSENTIALS OF GENERAL ANIMAL PATHOLOGY. — For seniors; juniors may elect. This is a continuation of Course 78, and is devoted to a study of some of the common pathological conditions by means of prepared sections, the aim being to demonstrate to the student abnormal animal histological structures commonly observed when material from various cases of animal diseases is prepared for microscopical study. Some of the biological products used in protecting animals against disease will be considered.
2 3-hour laboratory periods, credit, 3.
Associate Professor GAGE.
Prerequisite, Veterinary 78.

80. **III.** ESSENTIALS OF GENERAL ANIMAL PATHOLOGY. — For seniors; juniors may elect. As stated in Courses 78 and 79.
2 3-hour laboratory periods, credit, 3.
Associate Professor GAGE.
Prerequisite, Veterinary 79.

85. **I.** AVIAN PATHOLOGY. — For seniors; juniors may elect. A course in poultry diseases. The object of this course is to present information concerning the common diseases of poultry, their etiology, diagnosis and prevention. The work will consist of a systematic study of the diseases of the alimentary tract, liver and abdominal region, followed by a study of the diseases of the respiratory system, circulation and kidneys. The important disease-producing external and internal parasites will be considered; also diseases of the skin and reproductive organs. Lectures and demonstrations.
2 3-hour laboratory periods, credit, 3.
Associate Professor GAGE.

86. **II.** AVIAN PATHOLOGY. — For seniors; juniors may elect. As stated under Course 85, also devoted to the study of some of the special diseases of poultry. Recent methods used in the control of these diseases will be considered

and opportunity offered the student for demonstrating various disease processes by means of prepared slides. Lectures, demonstrations and laboratory work.

2 3-hour laboratory periods, credit, 3.
Associate Professor Gage.

Prerequisite, Veterinary 85.

87. **III.** Avian Pathology. — For seniors; juniors may elect. As stated under Courses 85 and 86.

2 3-hour laboratory periods, credit, 3.
Associate Professor Gage.

Prerequisite, Veterinary 86.

Zoölogy and Geology.

Professor Gordon, Dr. Ball.

ZOÖLOGY.

Required Courses.

25. **I.** General Zoölogy. — Sophomores. This course gives an outline of the underlying principles of zoölogy and an introduction to animal structure.

2 class hours. 2 2-hour laboratory periods, credit, 4.
Professor Gordon and Dr. Ball.

Elective Courses.

27. **III.** Elements of Mammalian or Avian Anatomy. — For sophomores; juniors and seniors may elect. This course is offered as a preparation for work in histology, embryology, general vertebrate zoölogy, etc. It also deals briefly with the essentials of physiology. The course is open to prospective students in physiological chemistry, microbiology, animal husbandry, veterinary sciences, etc.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Gordon and Dr. Ball.

Prerequisite, Zoölogy 25.

50. **I.** Synoptic Invertebrate Zoölogy. — For juniors; seniors may elect. This course gives a synopsis of the distinguishing characters of the different phyla and classes of invertebrates.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Gordon or Dr. Ball.

Prerequisite, Zoölogy 25.

51. **II.** Synoptic Invertebrate Zoölogy. — For juniors; seniors may elect. Continuation of Course 50.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Gordon or Dr. Ball.

Prerequisite, Zoölogy 50.

52. **III.** Synoptic Invertebrate Zoölogy. — For juniors; seniors may elect. Continuation of Courses 50 and 51.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Gordon or Dr. Ball.

Prerequisite, Zoölogy 51.

53. **I.** ELEMENTS OF MICROSCOPIC TECHNIQUE. — For juniors; seniors may elect. This course gives methods of preparing material for microscopic examination.

3 2-hour laboratory periods, credit, 3.
Professor GORDON.

Prerequisite, Zoölogy 25.

54. **II.** ELEMENTS OF HISTOLOGY. — For juniors; seniors may elect. This course involves preparation and study of normal animal tissues.

3 2-hour laboratory periods, credit, 3.
Professor GORDON.

Prerequisites, Zoölogy 27 and 53.

55. **III.** ELEMENTS OF HISTOLOGY. — For juniors; seniors may elect. Continuation of Course 54.

3 2-hour laboratory periods, credit, 3.
Professor GORDON.

Prerequisite, Zoölogy 54.

58. **II.** CONSERVATIONAL ZOÖLOGY. — For juniors; seniors may elect. This course aims to bring before the student the great public problems of the conservation of wild life, especially the natural fauna of the State, and the more complete utilization of various forms of animal life on the farm projects.

2 class hours. 1 2-hour laboratory period, credit, 3.
Dr. BALL.

75. **I.** SPECIAL ZOÖLOGY.[1] — Juniors, seniors, graduates, vocational students and others may ask, and in most cases may arrange, for special work in zoölogy. Such work as is desired in connection with an undergraduate major in another department, or in connection with a vocational course, should be formulated in consultation with officers having the major or vocational course in charge before the request for the work is made. For juniors, seniors and graduates who desire to extend their knowledge of zoölogy along more advanced or special lines, and who are adequately prepared, provision will gladly be made when possible. Work taken under this title may extend through the year, or may be for one term only.

1 class hour. 2 2-hour laboratory periods; hours by arrangement, credit, 3.
The DEPARTMENT.

Prerequisites, each case will be decided by itself.

76. **II.** SPECIAL ZOÖLOGY. — As stated under Course 75.

1 class hour. 2 2-hour laboratory periods, credit, 3.
The DEPARTMENT.

Prerequisites, each case will be decided by itself.

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[1] Those who desire work in zoölogy as a minor for the degree of master of science or for the degree of doctor of philosophy may elect certain courses offered to juniors or seniors, or may arrange for separate work. The graduate student who elects undergraduate courses must meet the requirements of the graduate standards of work and accomplishment.

77. **III.** Special Zoölogy. — As stated under Course 75.
1 class hour. 2 2-hour laboratory periods, credit, 3.
The Department.

Prerequisites, each case will be decided by itself.

78. **II.** Economic Zoölogy. — *Birds in their Relations to Crops, Insects and Man.* — For juniors and seniors; sophomores may elect. This course deals with the broad economic relations of the birds. The student is taught to know the birds and their migrations and distribution.
1 class hour. 2 2-hour periods, credit, 3.
Dr. Ball.

79. **III.** Economic Zoölogy. — *Birds in their Relations to Crops, Insects and Man.* — For juniors and seniors; sophomores may elect. In this course the student reviews what is known of the specific food habits of our most important economic birds, carries his studies into the field, and gets an intimate acquaintance with our Massachusetts birds and their habits in relation to crops, orchards, woodlands and to each other.
2 class hours. 1 2-hour laboratory period, credit, 3.
Dr. Ball.

Geology.

Required Courses.

2. **II.** Agricultural Geology. — Freshmen. The elements of geology in their application to agriculture.
2 class hours. Credit, 2.
Professor Gordon.

Elective Courses.

27. **III.** General Geology. — For sophomores; juniors and seniors may elect. Rock-forming minerals; rock types; rock weathering; dynamical, structural and surface geology. Lectures, map and field work.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor Gordon.

DIVISION OF THE HUMANITIES.

Professor Sprague.

Economics and Sociology.

Professor Sprague.

[The courses in economics and sociology are planned with the purpose of giving the student that knowledge and understanding of the important factors and problems in this field of study and life which every active citizen and educated man ought to have.]

[Heavy-faced type indicates the term in which the course is given. Numbering of courses: 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

Elective Courses.

26. **II.** Civilizations, Ancient and Modern. — For sophomores; others may elect. This course studies the evolutionary origin and history of man; characteristics of primitive man, departure from the animal status and beginnings of civilization; origin and development of industries, arts and sciences; the evolution of languages, warfare, migrations and social institutions; a study of the powerful natural and human forces that have brought man from the early stages to modern development; characteristic features of the leading civilizations and races of ancient and modern times; beneficial and dangerous factors in American life in view of the history of human civilization.
5 class hours. Credit, 5.
Professor Sprague.

50. **II.** Business and Industry. — For juniors and seniors. The forms, organization, administration and labor problems of business. This course is devoted to the following subjects: methods of organizing, financing and administering corporations and partnerships; forms of business administration, wholesaling, jobbing, retailing, advertising, credits and collections; systems of industrial remuneration for wage earners, co-operation and preserving industrial peace; problems concerned with protective legislation for workmen and employers, sweated industries, prison labor, child labor and industrial education.
5 class hours. Credit, 5.
Professor Sprague.

51. **I.** Introduction to Economic Principles and Problems. — For juniors. This course is devoted to the study of the following subjects: definitions of economic terms, such as wealth, capital, value, etc.; factors of production, exchange and consumption; principles of economic production, supply and demand, diminishing returns, division of labor, productive organization, concentration of capital and labor, trust and monopoly problems, public control of production and distribution; principles of exchange, theories of value, money and its problems; international trade, tariff and free trade theories, American merchant marine, reciprocity, and trade treaties; forms of income, wages, interest, rent, profits and the forces which govern them; principles of spending, economy, luxury, conservation of individual and national resources; principles and agencies for saving, investments, banks, building associations,

insurance of all kinds; schemes for social organization; socialism, communism, industrial democracy. Textbook and readings.
5 class hours. Credit, 5.
Professor SPRAGUE.

75. **I.** SOCIAL INSTITUTIONS AND SOCIAL REFORMS. — For seniors; juniors by permission. This course is devoted to the study of the social institutions, such as the family, the State, property, religions; and to such current problems as eugenics, race suicide, divorce, crime and delinquent classes, prison reform, prevention and treatment of dependents and defectives, poverty, its causes and preventions; constructive modern social reform movements for insurance of wage earners, protection of childhood, assurance of safety, health and play time for all classes. The correctional and charitable institutions of Massachusetts will be studied in considerable detail.
5 class hours. Credit, 5.
Professor SPRAGUE.

77. **III.** PUBLIC FINANCE, TAXATION, MONEY AND BANKING. — For seniors. This course studies systems and problems of taxation as they are found in Europe and America; objects for spending public revenue; public debts and methods of organizing them; systems of money and currency problems of America; types, methods and functions of banks; economic and financial crises and depressions in the United States; modern war finance. Readings and lectures.
5 class hours. Credit, 5.
Professor SPRAGUE.

History and Government.

Elective Courses.

50. **III.** GOVERNMENT. — For juniors; seniors may elect. This course will cover subjects as follows: forms and working methods of the governments of Great Britain, Germany, France, Russia, Switzerland, New Zealand and Canada; historic types and theories of government; forms and methods of Federal, State and local governments in America; progress and problems of democracy and new reform movements in organization and administration; new tendencies towards social legislation and extension of governmental control over broader interests of the people.
5 class hours. Credit, 5.
Professor SPRAGUE.

75. **II.** HISTORY OF NEW ENGLAND. — For seniors; juniors may elect. Treating New England as a geographical and political unit, this course aims to give a survey of its religious, social, economic and political history. The development of its institutions, the growth of its industries, the spread of its population to other sections of the country, its influence upon national character and politics are phases of the subject which will be discussed. Assigned readings and theses will be required.
3 class hours. Credit, 3.
Miss JEFFERSON.

Languages and Literature.

Professor LEWIS, Associate Professor NEAL, Associate Professor ASHLEY, Associate Professor MACKIMMIE, Assistant Professor PRINCE, Assistant Professor PATTERSON, Miss GOESSMANN, Mr. JULIAN, Mr. RAND.

ENGLISH.

Required Courses.

1. **I.** 2. **II.** 3. **III.** ENGLISH. — Freshmen. Composition. Intended to teach straight thinking, sound structure, clear and correct expression. Lectures, recitations, theme writing and conferences.
3 class hours each term. Credit, 3 each term.
Assistant Professor PRINCE, Assistant Professor PATTERSON and Mr. RAND.

25. **I.** 26. **II.** 27. **III.** ENGLISH. — Sophomores. A general reading course in English literature.
Two class hours each term. Credit, 2 each term.
Professor LEWIS and Miss GOESSMANN.

Elective Courses in English Language and Literature.

[The elective courses in English fall into two groups. Both groups are intended to increase the student's understanding and appreciation of literature. Group one (Courses 50, 51, 52, 53, 54 and 55) will, besides introducing the student to individual writers, emphasize the life and thought of the times, political, economic and social, in order that the student may realize literature as the expression of individual genius representing (by leading it or summarizing it) the thought and spirit of a period or a social unit. Group two (Courses 75, 77, 79 and 80) will tend more to emphasize form-characteristics, artistic quality or historical development of literary types, or individual great writers. Courses 50, 51, 55, 75, 79 and 80 are offered in 1918–19, Courses 52, 53, 54, 55, 77 and 80 are offered in 1919–20.]

50. **I.** ENGLISH POETRY IN THE NINETEENTH CENTURY (1919–20). — Alternates with Course 53 for juniors; seniors may elect. A course in history, appreciation and understanding. Some of the writers studied are Gray, Goldsmith, Burns, Coleridge, Wordsworth, Keats, Shelley, Scott and Byron.
3 class hours. Credit, 3.
Assistant Professor PATTERSON.

51. **II.** ENGLISH POETRY IN THE NINETEENTH CENTURY (1918–19). — Alternates with Course 54. Juniors; seniors may elect. In general conception this course is like Course 50. Tennyson, Browning, Mrs. Browning, Arnold, the Rossettis and Morris, Swinburne and Clough are among the authors to be studied.
3 class hours. Credit, 3.
Professor LEWIS.

57. **III.** ENGLISH POETRY IN THE NINETEENTH CENTURY. — For juniors; seniors may elect. As stated under Course 51.
2 class hours. Credit, 2.
Professor LEWIS.

Prerequisite, English 51.

52. **III.** English Writers from Milton to Pope (1918–19). — For juniors; seniors may elect. A survey course that will emphasize the leading writers of the periods, including Bacon, Milton, Dryden, Addison and the essayists, Swift and Pope. Given every second year.
3 class hours. Credit, 3.
Assistant Professor Patterson.

53. **I.** English Prose in the Nineteenth Century (1918–19). — For juniors; seniors may elect. A course in English prose paralleling Course 51. Some of the writers studied are Johnson, Sterne, Goldsmith, Burke, Miss Burney, Coleridge, Landor, Lamb, DeQuincey and Hazlitt.
3 class hours. Credit, 3.
Assistant Professor Patterson.

54. **II.** English Prose in the Nineteenth Century (1919–20). — For juniors; seniors may elect. This course parallels Course 51. Among the writers considered will be Macaulay, Carlyle, Ruskin, Newman and Arnold.
3 class hours. Credit, 3.
Professor Lewis.

58. **III.** English Prose in the Nineteenth Century. — For juniors; seniors may elect. As stated under Course 54.
2 class hours. Credit, 2.
Professor Lewis.

Prerequisite, English 54.

55. **II.** American Literature. — For juniors; seniors may elect. Intended to give a general survey of literature in America, especially in the nineteenth century, with an introduction to the work of the best known writers, and with especial attention to the relations between national life and history and national thought as expressed in literature. The usual authors — Irving, Cooper, Bryant, Poe, Longfellow, Emerson, Hawthorne, Whittier, Parkman, Lowell, Holmes, Whitman, Lanier — will be discussed, and attention will be given to southern and western authors. Present writers and tendencies will also receive some notice.
3 class hours. Credit, 3.
Assistant Professor Prince.

56. **III.** American Literature. — For juniors; seniors may elect. As stated under Course 55.
2 class hours. Credit, 2.
Assistant Professor Prince.

Prerequisite, English 55.

60. **I.** The Literature of Rural Life. — For juniors; seniors may elect. A critical and appreciative study of writers, both in prose and poetry, who have interpreted nature from the viewpoint of the lover of country life,

and those who have idealized agriculture, horticulture and other rural pursuits, together with those who have upheld as an ideal the development of a rural environment in cities.

3 class hours. Credit, 3.

Miss GOESSMANN.

61. **II.** THE LITERATURE OF RURAL LIFE. — For juniors; seniors may elect. As stated under Course 60.

2 class hours. Credit, 2.

Miss GOESSMANN.

Prerequisite, English 60.

75. **III.** PROSE FICTION. — Alternating courses in the short story and the novel. Seniors; juniors may elect. Readings, reports and discussions. Texts (short story): Neal's "Short Stories in the Making" and "To-day's Short Stories Analyzed." [Not given in 1917–18.]

3 class hours. Credit, 3.

Associate Professor NEAL.

79. **II.** THE DRAMA. — For seniors; juniors may elect. A cursory survey of early English drama, its origin, forms and meaning, will be followed by a careful study of Shakespeare. Four of his plays will be analyzed in detail, and many others will be read and discussed.

3 class hours. Credit, 3.

Mr. RAND.

80. **III.** THE DRAMA. — For seniors; juniors may elect. The course will trace the development of modern drama, especial attention being given to plays by Congreve, Goldsmith, Sheridan, Robertson, Jones, Pinero, Fitch, Shaw, Moody and Ibsen.

2 class hours. Credit, 2.

Mr. RAND.

Prerequisite, English 79.

RURAL JOURNALISM.

[The courses in journalism emphasize rural journalism. They aim to acquaint the student with the elementary problems and theory of journalism as a profession or vocation, and to exercise him, as far as conditions permit, in the commoner aspects of journalistic work, such as news-gathering, news-writing, desk-editing and editorial writing. By rural journalism is meant the application of journalistic principles in getting and suitably presenting material adapted to the nonurban rather than to the urban or metropolitan reader, so far as their interests are distinct. This includes agricultural journalism, but is by no means confined to that. As practical work, members of the classes supply a feature page for the "Springfield Union," and the "New Bedford Standard." Cordial unofficial relations are maintained with the college paper, "The Massachusetts Collegian."]

Elective Courses.

50. **I.** FOUNDATIONS OF WRITING: EXPOSITION. — For juniors; seniors may elect. Advanced composition; planning expository thought; expository structure; specimens, including contemporary articles from farm and rural life publications; some bulletin writing, including presentation of technical information for nontechnical readers.

3 class hours. Credit, 3.

Associate Professor NEAL.

51. **II.** Foundations of Writing: Narration and Description. — For juniors; seniors may elect. The fundamental elements of style, word-choice, diction, sentence form and paragraph types. Description of persons, places, objects, industries and productional processes, the temper and characteristic aspects of public gatherings, moods, behavior and character-sketching. Narration of incident, sustained action, events in series and the like, as in biography, dramatic situation, history and fiction.
3 class hours. Credit, 3.
Associate Professor Neal.

52. **III.** Foundations of Writing: Magazine Writing. — For seniors; juniors may elect. Study and writing of various forms of magazine and similar articles. [Not given in 1918–19.]
3 class hours or equivalent in laboratory. Credit, 3.
Associate Professor Neal.

Prerequisite, one or more junior courses in journalism, or experience in journalistic work.

53. **I.** News-gathering and News-writing. — For juniors; seniors may elect. The foundation aims and conceptions of journalism. Readings, lectures, quizzes and personal conferences; reporting on runs and on assignment; regular reading of a daily paper and of a weekly review or farm journal, with reports. Central purpose, to develop ability to pick out essentials from inessentials, perceive elements of interest, and present facts which appeal to the reader. This course and Courses 54 and 55 are suited to nonmajoring students whose vocation will require the popular presentation of technical or other information; *e.g.*, extension workers, county agents, agricultural school instructors, experiment-station editors, survey and other social service workers, men engaged in sociological or economic investigations, landscape architects and civil and sanitary engineers.
6 laboratory hours, credit, 3.
Associate Professor Neal.

54. **II.** News-gathering and News-writing. — For juniors; seniors may elect. As outlined under Course 53, except that students who have taken Course 53 will be assigned different readings, and may be given a larger amount of reporting or other writing.
6 laboratory hours, credit, 3.
Associate Professor Neal.

55. **III.** News-gathering and News-writing. — For juniors; seniors may elect. As stated under Courses 53 and 54.
6 laboratory hours, credit, 3.
Associate Professor Neal.

77. **I.** Editorial Materials and Methods. — For seniors; juniors may elect. Readings, quizzes, reports and personal conferences; regular reading of one daily paper and one weekly review or rural life periodical; writing of editorial articles; current events or history. Recommended to nonmajoring students who desire practice in discovering the significant aspects of matters of public attention and in effectively expressing comment thereon.
6 laboratory hours, credit, 3.
Associate Professor Neal.

78. **II.** Editorial Materials and Methods. — For seniors; juniors may elect. As stated under Course 77.

6 laboratory hours, credit, 3.
Associate Professor Neal.

79. **III.** Editorial Materials and Methods. — For seniors; juniors may elect. As stated under Course 77.

6 laboratory hours, credit, 3.
Associate Professor Neal.

80. **I.** Advanced Journalistic Practice. — Seniors. Preparation, editing and publication of a rural life page or periodical.

8 or 10 laboratory hours, credits, 4 or 5.
Associate Professor Neal.

81. **II.** Advanced Journalistic Practice. — Seniors. As stated under Course 80.

8 or 10 laboratory hours, credits, 4 or 5.
Associate Professor Neal.

82. **III.** Advanced Journalistic Practice. — Seniors. As stated under Course 80.

8 or 10 laboratory hours, credits, 4 or 5.
Associate Professor Neal.

Public Speaking.

Required Courses.

1. **I.** 2. **II.** 3. **III.** Public Speaking. — Freshmen. Freshmen public speaking is required in the first, second or third term, at the option of the instructor. The course is concerned with the actual problems which confront the man who would speak convincingly and persuasively. Much attention, therefore, is given to the preparation and delivery of extempore speeches. Textbook, Robinson's "Effective Public Speaking," supplemented by class work and discussions. First, second or third terms, as directed.

1 class hour. Credit, 1.
Assistant Professor Prince, Assistant Professor Patterson and Mr. Rand.

Elective Courses.

50. **I.** Argumentation. — For juniors; seniors may elect. The course aims to present the fundamental principles of argumentation as applied to oral and written discourse, and intends to develop in the student power to handle argument convincingly and persuasively. Lectures, discussions of leading questions of the day, practice in brief-drawing and the writing of forensics. Textbook, Foster's "Argumentation and Debating." The course is recommended for those who desire to enter the intercollegiate debates.

3 class hours. Credit, 3.
Assistant Professor Prince.

Prerequisite, Public Speaking, 1, 2 or 3.

51. **II.** Occasional Oratory. — For juniors; seniors may elect. The course involves a study of the elements of vocal expression and action; speeches on assigned subjects; prescribed reading; the preparation and delivery of several formal orations. Textbook, Shurter's "The Rhetoric of Oratory." The course is recommended for those who wish to enter the Flint contest.
3 class hours. Credit, 3.
Assistant Professor Prince.
Prerequisite, Public Speaking 1, 2 or 3.

French and Spanish.

Associate Professor Mackimmie.

French.

Required Courses.

1. **I.** 2. **II.** 3. **III.** Elementary French. — Freshmen; open upon arrangement to other students. The essentials of grammar are rapidly taught and will be accompanied by as much reading as possible. This course is required of freshmen presenting German for entrance who do not continue that language and have not studied French.
3 class hours each term. Credit, 3 each term.

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4. **I.** 5. **II.** 6. **III.** Intermediate French. — Freshmen; open upon arrangement to other students. Training for rapid reading. The reading of a number of short stories, novels and plays; composition, reports on collateral reading from periodicals and scientific texts in the library.
3 class hours each term. Credit, 3 each term.
Associate Professor Mackimmie.
Prerequisite, required of freshmen who present two years of French for entrance and do not take German.

Elective Courses.

25. **I.** Intermediate French. — For sophomores; open upon arrangement to other students. Training for rapid reading; the reading of a number of short stories, novels and plays; readings from periodicals and scientific texts in the library.
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisites, French 1, 2 and 3.

26. **II.** Intermediate French. — For sophomores; open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisite, French 25.

27. **III.** Intermediate French. — For sophomores; open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisite, French 26.

28. **I.** ADVANCED FRENCH. — For sophomores; open upon arrangement to other students. A reading course. Balzac's "Eugénie Grandet" and "Le Père Goriot," and other masterpieces of the nineteenth century; Brunetière's "Honoré de Balzac" and Harper's "Masters of French Literature;" readings in the library and written reports.
3 class hours. Credit, 3.

Prerequisites, French 4, 5 and 6.

29. **II.** ADVANCED FRENCH. — For sophomores; open upon arrangement to other students. As stated under Course 28.
3 class hours. Credit, 3.

Prerequisites, French 4, 5 and 6.

30. **III.** ADVANCED FRENCH. — For sophomores; open upon arrangement to other students. General view of the history of French literature; Kastner and Atkins' "History of French Literature." Representative works of the important periods will be studied in class. Outside reading will be required.
3 class hours. Credit, 3.

Prerequisites, French 25 and 26, or French 28 and 29.

50. **I.** SCIENTIFIC FRENCH. — For juniors; seniors may elect. This course is planned to meet the requirements of the individual student, and aims to equip him with exact English equivalents for the French scientific terms in his particular science. Word lists of scientific terms will be required, and also weekly readings and reports from scientific works in the subject in which he is majoring. Several scientific readers will be read.
3 class hours. Credit, 3.

Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

51. **II.** SCIENTIFIC FRENCH. — For juniors; seniors may elect. As stated under Course 50.
3 class hours. Credit, 3.

Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

52. **III.** SCIENTIFIC FRENCH. — For juniors; seniors may elect. As stated under Course 50.
3 class hours. Credit, 3.

Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

75. **I.** FRENCH LITERATURE. — For seniors; juniors may elect. The object of Courses 75, 76 and 77 is to give an introduction to recent movements

in French literature. Course 75 will deal with the drama, and plays by Augier, A. Dumas, fils, Delavigne and some contemporary dramatists will be read and studied.
3 class hours. Credit, 3.
Associate Professor MACKIMMIE.
Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

76. **II.** FRENCH LITERATURE. — For seniors; juniors may elect. This course deals with the novel. Works by Flaubert, the De Goncourts and Zola will be read. Written reports are required on outside reading.
3 class hours. Credit, 3.
Associate Professor MACKIMMIE.
Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

77. **III.** FRENCH LITERATURE. — For seniors; juniors may elect. Modern criticism. Sainte-Beuve, "Causeries du Lundi" (Harper) and works by Taine and Renan. Reference book, Lanson's "Histoire de la Litterature Française."
3 class hours. Credit, 3.
Associate Professor MACKIMMIE.
Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

SPANISH.

Elective Courses.

50. **I.** ELEMENTARY SPANISH. — For juniors; seniors may elect. Open to other students upon arrangement. Grammar, with special drill in pronunciation; exercises in conversation and composition. Reading from a reader and selected short stories.
3 class hours. Credit, 3.
Associate Professor MACKIMMIE.

51. **II.** ELEMENTARY SPANISH. — For juniors; open to other students upon arrangement. As stated in Course 50.
3 class hours. Credit, 3.
Associate Professor MACKIMMIE.
Prerequisite, Spanish 50.

52. **III.** ELEMENTARY SPANISH. — For juniors; open to other students upon arrangement. As stated in Course 50.
3 class hours. Credit, 3.
Associate Professor MACKIMMIE.
Prerequisite, Spanish 51.

75. **I.** MODERN SPANISH AUTHORS. — Seniors. Reading from modern Spanish novel and drama. Translation of English into Spanish. Private reading.
3 class hours. Credit, 3.
Associate Professor MACKIMMIE.
Prerequisite, Spanish 52.

76. **II.** Modern Spanish Authors. — Seniors. As stated in Course 75.
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisite, Spanish 75.

77. **III.** Modern Spanish Authors. — Seniors. As stated in Course 75.
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisite, Spanish 76.

German and Music.

Associate Professor Ashley, Mr. Julian.

German.

Required Courses.

1. **I.** 2. **II.** 3. **III.** Elementary German. — Freshmen; open upon arrangement to other students. Grammar composition and reading. Especial attention is given to oral work in German and to translation of English into German. Required of those presenting French for entrance who do not continue that language and have not studied German.
3 class hours, each term. Credit, 3 each term.
Associate Professor Ashley and Mr. Julian.

4. **I.** 5. **II.** 6. **III.** Intermediate German. — Freshmen; open upon arrangement to other students. Selected works of Schiller, Heine and Goethe. Grammar review and advanced prose composition.
3 class hours each term. Credit, 3 each term.
Associate Professor Ashley.
Prerequisite, required of freshmen who present two years of German for entrance and do not take French.

Elective Courses.

25. **I.** Intermediate German. — For sophomores; open upon arrangement to other students. Reading of such works as Sudermann's "Frau Sorge," "Wilhelm Tell," "Die Journalisten," etc. Grammar review.
3 class hours. Credit, 3.
Mr. Julian.
Prerequisites, German 1, 2 and 3.

26. **II.** Intermediate German. — For sophomores; open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit, 3.
Mr. Julian.
Prerequisite, German 25.

27. **III.** Intermediate German. — For sophomores; open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit, 3.
Mr. Julian.
Prerequisite, German 26.

28. **I.** ADVANCED GERMAN. — For sophomores; open upon arrangement to other students. Reading and studying of Goethe's most important literary productions.
3 class hours. Credit, 3.
Associate Professor ASHLEY.

Prerequisites, German 4, 5 and 6.

29. **II.** ADVANCED GERMAN. — For sophomores; open upon arrangement to other students. Development of the German novel; rapid reading of great novelists.
3 class hours. Credit, 3.
Associate Professor ASHLEY.

Prerequisite, German 28.

30. **III.** ADVANCED GERMAN. — For sophomores; open upon arrangement to other students. As stated under Course 29.
3 class hours. Credit, 3.
Associate Professor ASHLEY.

Prerequisite, German 29.

50. **I.** SCIENTIFIC GERMAN. — For juniors; seniors may elect. Reading in German of modern magazine articles and works of a scientific nature. Different work assigned according to needs of individual students.
3 class hours. Credit, 3.
Associate Professor ASHLEY.

Prerequisites, German 4, 5 and 6, or German 25, 26 and 27.

51. **II.** SCIENTIFIC GERMAN. — For juniors; seniors may elect. As stated under Course 50.
3 class hours. Credit, 3.
Associate Professor ASHLEY.

Prerequisite, German 50.

52. **III.** SCIENTIFIC GERMAN. — For juniors; seniors may elect. As stated under Course 50.
3 class hours. Credit, 3.
Associate Professor ASHLEY.

Prerequisite, German 51.

75. **I.** GERMAN LITERATURE. — Seniors. Advanced language and literary study. Conducted entirely in German. Lectures on German literature and history; life, customs and travel in Germany. Collateral readings, including masterpieces of different epochs, such as "Niebelungenlied," Goethe's "Faust" and one modern typical drama.
3 class hours. Credit, 3.
Associate Professor ASHLEY.

Prerequisites, German 28, 29 and 30.

76. **II.** GERMAN LITERATURE. — Seniors. As stated under Course 75.
3 class hours. Credit, 3.
Associate Professor ASHLEY.

Prerequisite, German 75.

77. **III.** GERMAN LITERATURE. — Seniors. As stated under Course 75.
3 class hours. Credit, 3.
Associate Professor ASHLEY.
Prerequisite, German 76.

78. **I.** CONVERSATION AND COMPOSITION. — For seniors; juniors may elect. Translating connected English into German. Reproducing outside readings in German orally in class.
1 class hour. Credit, 1.
Associate Professor ASHLEY.
Prerequisites, German 4, 5 and 6, or German 25, 26 and 27.

79. **II.** CONVERSATION AND COMPOSITION. — For seniors; juniors may elect. As stated under Course 78.
1 class hour. Credit, 1.
Associate Professor ASHLEY.
Prerequisite, German 78.

80. **III.** CONVERSATION AND COMPOSITION. — For seniors; juniors may elect. As stated under Course 78.
1 class hour. Credit, 1.
Associate Professor ASHLEY.
Prerequisite, German 79.

MUSIC.

Elective Courses.

50. **I.** HISTORY AND INTERPRETATION OF MUSIC. — For juniors; seniors may elect. History of music among the ancients; medieval and secular music; epoch of vocal counterpoint; development of monophony opera and oratorio; life and works of the greatest representatives of the classical school, — Bach, Händel, Haydn, Gluck and Mozart.
1 class hour. Credit, 1.
Associate Professor ASHLEY.

51. **II.** HISTORY AND INTERPRETATION OF MUSIC. — For juniors; seniors may elect. A continuation of Course 50. The Romantic school; Beethoven, Schubert, Weber, Mendelssohn, Schumann, Chopin, Berlioz and Liszt; Wagner and the opera.
1 class hour. Credit, 1.
Associate Professor ASHLEY.

52. **III.** HISTORY AND INTERPRETATION OF MUSIC. — For juniors; seniors may elect. The Modern school and Modern composers.
1 class hour. Credit, 1.
Associate Professor ASHLEY.

DIVISION OF RURAL SOCIAL SCIENCE.

President BUTTERFIELD.

[Heavy-faced type indicates the term in which the course is given. Numbering of courses 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

Agricultural Economics.

Professor CANCE, Mr. WILKINSON.

Required Course.

26. **II.** AGRICULTURAL INDUSTRY AND RESOURCES. — Sophomores. A descriptive course dealing with agriculture as an industry and its relation to physiography, movement of population, supply of labor, commercial development, transportation, public authority and consumers' demand. The principal agricultural resources of the United States will be studied with reference to commercial importance, geographical distribution, present condition and means of increasing the value of the product and cheapening cost of production. Lectures, assigned readings, class topics and discussions.
5 class hours. Credit, 5.
Professor CANCE and Mr. WILKINSON.

Elective Courses.

50. **I.** ELEMENTS OF AGRICULTURAL ECONOMICS. — For juniors; seniors may elect. This course is designed to accompany or follow the course in elements of economics. It deals with the economic principles underlying the welfare and prosperity of the farmer and those institutions upon which his economic success depends; the economic elements in the production and distribution of agricultural wealth; means of exchange; principles of rural credit; problems of land tenure and land values; taxation of farm property; and the maintenance of the economic status of the farmer. Lectures, text, readings, topics and field work.
5 class hours. Credit, 5.
Professor CANCE.

51. **III.** HISTORICAL AND COMPARATIVE AGRICULTURE. — For juniors; seniors may elect. A general survey of agriculture, ancient and modern; feudal and early English husbandry; the later development of English agriculture; the course of agriculture in the United States, with special emphasis on the development of agriculture in New England. An attempt will be made to measure the influence of times, peoples and countries in producing different systems of agriculture, and to ascertain the causes now working to effect agricultural changes. Lectures, readings and library work. Students in education and rural journalism should find this course helpful.
5 class hours. Credit, 5.
Mr. WILKINSON.

52. **II.** CO-OPERATION IN AGRICULTURE. — For juniors; seniors may elect. The course treats of the history, principles and business relations of agricultural co-operation. (1) A survey of the development, methods and economic results of farmers' organizations and great co-operative movements;

(2) the business organization of agriculture abroad, and the present aspects and tendencies in the United States; (3) the principles underlying successful co-operative endeavor among farmers, practical working plans for co-operative associations, with particular reference to credit and purchase and the marketing of perishable products. Lectures, text, assigned readings and practical exercises.

5 class hours. Credit, 5.

Professor Cance.

53. **III.** The Agricultural Market.—For juniors; seniors and graduate students may elect. A study of the forces and conditions which determine the prices of farm products and the mechanism, methods and problems concerned with transporting, storing and distributing them. Supply and demand, course of prices, terminal facilities, the middleman system, speculation in agricultural products, protective legislation, the retail market and direct sales are taken up. The characteristics and possibilities of the New England market are given special attention. Lectures, readings, assigned studies and field work.

5 class hours. Credit, 5.

Professor Cance.

76. **II.** Transportation of Agricultural Products. — For seniors and graduate students; juniors may elect. This course deals with transportation in the United States, covering highways, waterways, railways and electric ways, with reference to the facilities for and cost of transporting farm products, opening up new agricultural areas or industries, and contributing to the wealth and welfare of the agricultural population. Lectures, text and field work.

5 class hours. Credit, 5.

Professor Cance.

77. **I.** Problems in Agricultural Economics. — For seniors and graduate students; juniors may elect. An advanced course for students desirous of studying more intensively some of the economic problems affecting the farmer. Some of these are: land problems, — land tenure, size of farms, causes affecting land values, private property in land, taxation of farm property; special problems, — cost of producing farm products, farm labor in New England, immigration, agricultural credit. Opportunity will be given, if practicable, for field work, and students will be encouraged to pursue lines of individual interest.

5 class hours. Credit, 5.

Professor Cance and Mr. Wilkinson.

78. **III.** Agricultural Credit Facilities. — For seniors and juniors. The legitimate use of credit in the production, storing and marketing of agricultural products. A brief survey of the development of credit institutions. National and State rural credit laws. Farm land banks, credit associations, and other means of securing personal credit. The topics will be discussed from the standpoints of dealers in agricultural produce, the landowning farmer, the tenant and the farm laborer; special attention will be given to the credit needs of the college graduate.

3 class hours. Credit, 3.

Mr. Wilkinson.

80. **I.** Seminar. — For seniors and graduate students. Research in agricultural economics and history; problems of New England agriculture. Library work and reports. If desirable some other topic may be substituted. Hours to be arranged.
1 2-hour laboratory period, credit, 1.
The Department.

81. **II.** Seminar. — For seniors and graduate students. As stated in Course 80.
1 2-hour laboratory period, credit, 1.
The Department.

82. **III.** Seminar. — For seniors and graduate students. As stated in Course 80.
1 2-hour laboratory period, credit, 1.
The Department.

Agricultural Education.

Professor Hart.

Elective Courses.

50. **I.** Meaning of Education (Psychology). — For juniors; seniors may elect. For teachers and others desiring an introduction to mental science. A study of the development, structure and functions of the nervous system and the sense organs; the development and nature of mental activities; the nature of the learning processes.
5 class hours. Credit, 5.
Professor Hart.

51. **II.** Teachers' Training Course. — For juniors; seniors may elect. Primarily for teachers. A study of agricultural education; the theory and practice of teaching; rural school organization; methods of instruction; the place and function of agriculture in the course of study for both rural and city schools; planning and practical work in school and home gardens.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Professor Hart.

53. **III.** History and Philosophy of Education. — For juniors; seniors may elect. For teachers and others desiring an introduction to educational theories. A study of educational ideals and movements as exemplified by leading nations and races; the growth of educational institutions as influenced by science and industry; the history and meaning of industrial and agricultural education.
5 class hours. Credit, 5.
Professor Hart.

80. **I.**, 81. **II.**, 82. **III.**, 83. **IV.** Teachers' Training Course. — For seniors. Supervised apprentice teaching.
1 conference or more. 3 to 5 class periods of teaching, credit, 5.
Professor Hart.

75. **I.** Problems in Rural Education. — For seniors. For teachers or others interested in special phases of education, such as child development, physical and mental; school organization; rural schools; secondary schools; school programs; grading and promotion of pupils; school grounds and school architecture and equipment; normal schools and the preparation of teachers; agricultural teaching and agricultural schools.
4 class hours. Credit, 4.
Professor Hart.

76. **II.** Problems in Rural Education. — Seniors. As stated under Course 75.
4 class hours. Credit, 4.
Professor Hart.

77. **II.** Extension and County Agent Work. — For seniors. The course consists chiefly of library research work. Each student will be required to produce one or more complete lectures under guidance both as to method of preparation and subject-matter, and one or more demonstrations. These lectures will be presented to public audiences in the presence of a board of critics. Some instruction will be given in organization and administration of the Extension Service. The Extension Service will be responsible for the public presentation and criticism. The student's major adviser will be responsible for the accuracy of the subject-matter. The Department of Agricultural Education will be responsible for the preparation of the lectures.
2 class hours. 4 2-hour laboratory periods, credit, 5.
Professor Hart.

78. **III.** Extension and County Agent Work. — For seniors. As stated under Course 77.
2 class hours. 4 2-hour laboratory periods, credit, 5.
Professor Hart.

Rural Sociology.

Professor Phelan, President Butterfield, Professor Hart, Mr. Novitski.

Required Course.

27. **III.** Elements of Rural Sociology. — Sophomores. A broad survey of the field of rural sociology, including such topics as the origin of rural sociology, its methods and problems; relation of sociological to the scientific and technical aspects of agricultural problems; the development of the rural community in New England and the west, religious, educational and social ideals of rural people; characteristics and influence of the rural environment, the movement of the rural population, the effects of immigration; rural institutions, the school, the church, local government, effects of modern conditions of life on rural institutions; rural organization; problems of progress, an analysis of the needs of rural life in its further development. Lectures, readings and essays on assigned topics.
3 class hours. Credit, 3.
Professor Phelan and Mr. Novitski.

Elective Courses.

50. **I.** SOCIAL CONDITION OF RURAL PEOPLE. — For juniors; seniors may elect. A. The rural status: composition of the rural population, nature, extent and causes of diseases and accidents, health agencies of control; extent and causes of rural delinquency and dependency, conditions of temperance of sexual morality and family integrity; child labor, women's work and position; standard of living, size of family; cultural ideals; community consciousness and activity; standards of business conduct and of political ethics.

B. Rural social psychology: characteristics of the rural mind, character of hereditary and environmental influence; nature and effect of face-to-face groups; fashion, conventionality, custom, character of discussion and of public opinion.

3 class hours. Credit, 3.

Professor PHELAN.

51. **II.** RURAL GOVERNMENT. — For juniors; seniors may elect. A general survey of the development of rural government in the United States, origin of the New England town, its influence upon the west, advantages, development of efficiency, county government, the influence of the farmer in legislation, good roads movement, credit, facilities, taxation, boards of agriculture, agricultural colleges and experiment stations in relation to rural welfare; national government; a general survey of political organizations and movements among farmers in the United States and foreign countries and their influence in shaping legislation; relation of the Department of Agriculture, postal system, the various national commissions and agencies to rural welfare. Lectures, readings, written exercises on assigned topics.

3 class hours. Credit, 3.

Professor PHELAN and Mr. NOVITSKI.

52. **III.** RURAL ORGANIZATION. — For juniors; seniors may elect. A study of the organized agencies by which rural communities carry on their various forms of associated life, particularly a study of the ways by which the domestic, economic, cultural, religious and political institutions contribute to rural betterment; principles underlying leadership, qualifications of the paid leader and the lay leader; the field of rural social service, national, State and local, preparation and opportunity for service; rural community building, a study of organized ways and means by which aid is given local communities.

3 class hours. Credit, 3.

President BUTTERFIELD.

75. **I.** FARMERS' ORGANIZATIONS. — For seniors; juniors may elect. The history, purposes and achievements of the grange, the Farmers' Union, farmers' clubs, village improvement associations, boys' clubs, etc.; the method, scope and history of local, State and national associations formed about some farm product, their influence in forming class consciousness and in shaping agrarian legislation; need of federation. Lectures, readings and essays on assigned topics.

3 class hours. Credit, 3.

Professor PHELAN.

76. **I.** Field Work in Rural Sociology. — For seniors; juniors may elect. This course is designed to meet the needs of students who wish to do some constructive work in rural social service while still in college. The work will be carried on in co-operation with the various college agencies engaged in rural service. Any project for which credit in this course is to be asked must first have the approval of the head of the department.

From 2 to 6 laboratory hours, credits, 1 to 3.
Professor Phelan.

Prerequisites, Rural Sociology 27 and 52.

77. **II.** Rural Social Surveys. — For seniors; juniors may elect. A careful study of the theory and function of statistics, the limitations and difficulties in the use of statistics, the interpretation of statistical data, various methods of graphic representation; a study of surveys, kinds and use, method of gaining information, the basis for conclusions, value of information gained. Text and lectures.

3 class hours. Credit, 3.
Professor Phelan.

78. **II.** Rural and Business Law. — For seniors; juniors may elect. The work of this course will cover such points as land, titles, public roads, rights incident to ownership of live stock, contracts, commercial paper and distinctions between personal and real property. Text, written exercises, lectures and class discussions.

5 class hours. Credit, 5.
Professor Hart.

79. **I.** Seminar. — Credits, 1 to 3. Professor Phelan.

80. **II.** Seminar. — Credits, 1 to 3. Professor Phelan.

81. **III.** Seminar. — Credits, 1 to 3. Professor Phelan.

GENERAL DEPARTMENTS.

Military Science and Tactics.

Col. R. H. Wilson, U. S. A., retired; Ordnance Sergeant J. J. Lee, U. S. A., retired.

A Reserve Officers Training Corps was established at this college pursuant to paragraph IX., Bulletin 6, Jan. 29, 1917. Instruction in military science and tactics of an infantry unit of the Reserve Officers Training Corps was begun on April 1, 1917, and has been continued during the year, following the course of training prescribed for infantry units of the senior division in General Orders No. 49, War Department, Sept. 20, 1916.

The department of Military Science and Tactics conducts its work in conjunction with the Department of Physical Education and Hygiene, in accordance with the following statement: —

All candidates for a degree in a four-year course must take for three years three full hours a week of physical training. This work must be under college supervision. At least two years of the work must be taken in the Department of Military Science and Tactics, in accordance with the requirements of the War Department; the rest is to be taken in the Department of Physical Education.

Under this arrangement, the practical courses (drill) in military science are given in the first and third terms; the corresponding courses in physical education in the second term.

Under act of Congress (July 2, 1862), military instruction under a regular army officer is required in this college of all able-bodied male students. Men are excused from the exercises of this department only upon presentation of a certificate given by the college physician; minor disabilities which might bar enlistment are not considered. Students excused from military duty may be required to take equivalent work. The object of the instruction is to disseminate military knowledge in order that in emergency trained men may be found to command volunteer troops; but a further object is to give physical exercise, to teach obedience without detracting from self-respect, and to develop the bearing and courtesy that are as becoming in a citizen as in a soldier. Absences and other offences of military nature, and those of which the military instructor may take cognizance as affecting discipline, are dealt with by the commandant in accordance with the regulations of the department; but delinquencies in theoretical instruction not strictly military in their nature are dealt with in accordance with the rules of the faculty.

Cadets in the graduating class who have shown special aptitude for military service are reported to the Adjutant-General of the United States army and to the Adjutant-General of Massachusetts; in making appointments from civil life to the regular or volunteer army, preference is given to those who have been so reported. The names of the three most distinguished are published in the "Official Register of the United States Army." Assignments to the band are made by the military instructor.

Members of the Reserve Officers Training Corps who elect the advanced courses and are recommended by the President and the commandant, may take the course prescribed for the Reserve Officers Corps by entering a training company for six months, being paid at the rate of $100 per month while attending the camp. They obligate themselves to serve in the Reserve Officers Corps for ten years, receiving pay of their rank when called into the service of the United States for any duty.

The required uniform is of olive drab woolen cloth, costing about $34, of which $14 is borne by the government. It is worn by all cadets when on military duty, and may be worn at other times, and will be considered the property of the United States for one scholastic year. Students upon entering college are required to deposit about $20 with the college treasurer to cover the cost of the uniform. The sale of old uniforms is prohibited unless the consent of the commandant be obtained.

[Heavy-faced type indicates the term in which the course is given. Numbering of courses: 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

Required Courses.

1. **I.** Tactics. — Freshmen. Theoretical instruction through the school of the soldier, squad and company. Lectures on military subjects.
1 class hour. Credit, 1.
Colonel Wilson.

2. **II.** Tactics. — Freshmen. As stated under Course I.
1 class hour. Credit, 1.
Colonel Wilson.

3. **III.** Tactics. — Freshmen. Theory of target practice, map reading, service of security. Personal hygiene.
1 class hour. Credit, 1.
Colonel Wilson.

4. **I.** Drill. — Freshmen. Practical instruction in Infantry Drill Regulations, school of the soldier, squad and company, close and extended order. Preliminary instruction, position, sighting and aiming drills. Gallery practice.
1 class hour. Credit, 1.
Colonel Wilson and Sergeant Lee.

5. **II.** Drill. — Freshmen. Physical drill, Koehler's Manual. Gallery practice.
1 class hour. Credit, 1.
Professor Hicks and Sergeant Lee.

6. **III.** Drill. — Freshmen. As stated under Course 4.
1 class hour. Credit, 1.
Colonel Wilson and Sergeant Lee.

25. **I.** Tactics. — Sophomores. United States Infantry Drill Regulations, to include school of the battalion and combat. Small-arms firing regulations. Lectures, map reading, camp sanitation and camping expedients.
1 class hour. Credit, 1.
Colonel Wilson.

26. **II.** Tactics. — Sophomores. As stated under Course 25.
1 class hour. Credit, 1.
Colonel Wilson.

27. **III.** Tactics. — Sophomores. Lectures on military history, service of information and security, marches and camps.
1 class hour. Credit, 1.
Colonel Wilson.

28. **I.** Drill. — Sophomores. Infantry Drill Regulations to include school of the battalion, ceremonies, first-aid instruction. Range and gallery practice, and combat firing.
1 class hour. Credit, 1.
Colonel Wilson and Sergeant Lee.

29. **II.** Drill. — Sophomores. Physical drill, Koehler's Manual. Gallery practice.
1 class hour. Credit, 1.
Professor Hicks and Sergeant Lee.

30. **III.** Drill. — Sophomores. As stated under Course 28.
1 class hour. Credit, 1.
Colonel Wilson and Sergeant Lee.

Elective Courses.

50. **I.** MILITARY SCIENCE. — Juniors. Minor tactics; field orders (studies in minor tactics); map maneuvers.
1 class hour. Credit, 1.
Colonel WILSON.

51. **II.** MILITARY SCIENCE. — Juniors. Minor tactics; elements of international law; property accountability; method of obtaining supplies and equipment.
3 class hours. Credit, 3.
Colonel WILSON.

52. **III.** MILITARY SCIENCE. — Juniors. As stated under Course 51.
3 class hours. Credit, 3.
Colonel WILSON.

53. **I.** DRILL. — Juniors. Duties consistent with rank as cadet officers or noncommissioned officers in connection with the practical work and exercises laid down for the unit.
1 class hour. Credit, 1.
Colonel WILSON and Sergeant LEE.

54. **II.** DRILL. — Juniors. As stated under Course 53.
1 class hour. Credit, 1.
Colonel WILSON and Sergeant LEE.

55. **III.** DRILL. — Juniors. As stated under Course 53.
1 class hour. Credit, 1.
Colonel WILSON and Sergeant LEE.

75. **I.** MILITARY SCIENCE. — Seniors. Tactical problems, small forces, all arms combined; map maneuvers; court-martial proceedings.
3 class hours. Credit, 3.
Colonel WILSON.

76. **II.** MILITARY SCIENCE. — Seniors. International relations of America from discovery to present day, and gradual growth of principles of international law, embodied in American diplomacy, legislation and treaties.
3 class hours. Credit, 3.
Colonel WILSON.

77. **III.** MILITARY SCIENCE. — Seniors. Lectures on psychology of war and general principles of strategy.
3 class hours. Credit, 3.
Colonel WILSON.

78. **I.** DRILL. — Seniors. As stated under Course 53.
1 class hour. Credit, 1.
Colonel WILSON and Sergeant LEE.

79. **II.** Drill. — Seniors. As stated under Course 53.
1 class hour. Credit, 1.
Colonel Wilson and Sergeant Lee.

80. **III.** Drill. — Seniors. As stated under Course 53.
1 class hour. Credit, 1.
Colonel Wilson and Sergeant Lee.

Officers and noncommissioned officers conduct drill of lower classes. Field officers and captains are appointed from this class. The positions in every case are obtained by competition. It is to be understood that cadets obtaining these positions will be reported to the Adjutant-General of the army as distinguished cadets.

Physical Education and Hygiene.

Professor Hicks, Assistant Professor Gore,[1] Mr. Dickinson.[2]

[All classified undergraduate male students are given a physical examination upon entering.]

Men.

Required Courses.

1. **I.** Hygiene. — Freshmen. Lectures on personal hygiene.
1 class hour. Credit, 1.
Professor Hicks.

2. **I.** Recreation. — Freshmen. Outdoor games.
1 laboratory hour. Credit, third term.
Mr. Dickinson.

3. **III.** Recreation. — Freshmen. Outdoor games.
1 laboratory hour. Credit for Nos. 2 and 3, 1.
Mr. Dickinson.

25. **I.** Recreation. — Sophomores. Outdoor games.
1 laboratory hour. Credit, third term.
Mr. Dickinson.

26. **III.** Recreation. — Sophomores. Outdoor games.
1 laboratory hour. Credit for Nos. 25 and 26, 1.
Mr. Dickinson.

Course Elective during Emergency.

51. **II.** Gymnastics. — Juniors not members of Reserve Officers Training Corps.
2 laboratory hours. Credit, 1.
Professor Hicks.

Elective Course.

77. **III.** Training Course. — Seniors. Election by permission only. History of physical education and supervision of athletics.
1 class hour. Credit, 1.
Professor Hicks.

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[1] On leave.

[2] Temporary substitute.

WOMEN.

Required Courses.

4. **I.** RECREATION. — Freshmen. Outdoor games.
3 laboratory hours. Credit, 1.

5. **II.** GYMNASTICS. — Freshmen. Dancing, Swedish games, etc.
3 laboratory hours. Credit, 1.

6. **III.** RECREATION. — Freshmen. Outdoor games.
3 laboratory hours. Credit, 1.

27. **I.** RECREATION. — Sophomores. Outdoor games.
3 laboratory hours. Credit, 1.

28. **II.** GYMNASTICS. — Sophomores. Dancing, Swedish games, etc.
3 laboratory hours. Credit, 1.

29. **III.** RECREATION. — Sophomores. Outdoor games.
3 laboratory hours. Credit, 1.

Elective Courses.

50. **II.** GYMNASTICS. — Juniors. Dancing, Swedish games, etc.
3 laboratory hours. Credit, 1.

76. **II.** GYMNASTICS. — Seniors. Dancing, Swedish games, etc.
3 laboratory hours. Credit, 1.

THE GRADUATE SCHOOL.

THE GRADUATE SCHOOL.

KENYON L. BUTTERFIELD, A.M., LL.D., President of the College.

CHARLES H. FERNALD, Ph.D., Honorary Director of the Graduate School.

CHARLES E. MARSHALL, Ph.D., Director of the Graduate School and Professor of Microbiology.

GRADUATE STAFF, 1916-17.

Associate Professor BEAUMONT, Professor CANCE, Professor CHAMBERLAIN, Assistant Professor O. L. CLARK, Professor CRAMPTON, Professor FERNALD, Professor FOORD, Professor GRAHAM, Assistant Professor HECHT, Dr. ITANO, Assistant Professor JONES, Professor LINDSEY, Professor McNUTT, Professor OSMUN, Professor PETERS, Professor PHELAN, Professor SEARS, Professor WAUGH, Director MARSHALL, President BUTTERFIELD; Mr. WATTS, Secretary.

Graduate courses leading to the degrees of master of science and doctor of philosophy have been given for a number of years; the degrees of master of agriculture and doctor of agriculture are now granted to meet strictly professional needs. The number of requests for each of these courses is apparently increasing. In recognition of the benefits to be derived from a separate organization, a distinct graduate school has been established for the purpose of fitting graduates of this and other institutions for teaching in colleges, high schools and other public schools; for positions as government, State and experiment-station specialists in farm management, dairying, live-stock husbandry, poultry science, agronomy, landscape gardening, pomology, vegetable gardening and floriculture; for positions as bacteriologists, botanists, chemists, entomologists; and for numerous other positions requiring a great amount of scientific and professional knowledge, training and experience.

ORGANIZATION.

The school is based upon the department as the unit, and the apprenticeship system as the most effective means of instruction. This gives to the student individuality in treatment and an intimacy with actual conditions of work and operations. Besides, each student is assigned to an advisory committee, composed of the instructor in charge of his major subject as chairman, and instructors in charge of his minor subjects as members, which directs his graduate studies. The chairmen of all these committees together constitute the graduate staff, which controls the policy of the graduate school.

ADMISSION.

Admission to the graduate school will be granted: —

1. To graduates of the Massachusetts Agricultural College.
2. To graduates of other institutions of good standing who have received a bachelor's degree substantially equivalent to that conferred by this college.

In case an applicant presents his diploma from an institution of good standing, but has not, as an undergraduate, taken as much of the subject he selects for his major as is required of undergraduates at the Massachusetts Agricultural College, he will be required to make up such parts of the undergraduate work in that subject as the instructor in charge may consider necessary. He shall do this without credit toward his advanced degree.

Admission to the graduate school does not necessarily admit to candidacy for an advanced degree, — students holding a bachelor's degree being in some cases permitted to take graduate work without becoming candidates for higher degrees.

Applications for membership in the graduate school should be presented to the director of the school. Full statements of the applicant's previous training, of the graduate work desired, and of the amount and kind of work already done by him as an undergraduate should be submitted, together with a statement whether the applicant desires to work for a degree.

Registration is required of all students taking graduate courses, the first registration being permitted only after the student has received an authorization card from the director.

Nature, Methods and Requirements of Graduate Work.

Graduate work differs from undergraduate work in its purposes and methods. The primary aims of the instructor are emphasized in an attempt to have the student adjust himself and place himself in his environment; develop the rule of self-direction and self-instruction; acquire the power of accurate reasoning; gain proficiency and skill in his selected field of study or practice; and obtain an appreciative and discriminative insight into experimentation and original research. Methods are not devised, therefore, for attractiveness, entertainment and superficial reviews, but for the creation of initiative and profound thought, thorough acquaintance with detail, independent advance and industrious habits. Careful readings, lectures, conferences, surveys, laboratory exercises and field work are some of the agencies utilized.

All members of the graduate school are required to attend the course of lectures designed to supplement the technical work of all graduate studies. These lectures will be given once each week, and the students will be held responsible for the work. [Suspended during continuance of the war.]

Candidates for the degree of master of science are required to prosecute two subjects, one of which shall be designated as a major and the other as a minor. These subjects may not be selected in the same department. An original thesis is considered a part of the major subject.

Candidates for the degree of doctor of philosophy are required to prosecute three subjects, one of which shall be designated as the major and the others as minors. No two of these subjects may be taken in the same department. An original thesis shall be considered a part of the major subject.

Candidates for the degree of master of agriculture are allowed greater privileges in the selection of subjects, but will be required to select a major and such other supporting lines of study as will be necessary properly to equip the individual professionally.

Candidates for the degree of doctor of agriculture are required to select a major and such other subjects as will develop the major in its greatest intensity and comprehensiveness. Successful experience is also requisite, together with a thesis which represents a masterly survey or intimate study through accurate application of some phase of the major subject.

Candidates for the degree of master of landscape architecture will be expected to conform to the established courses of the department, and to the requirements of the department in the preparation of a thesis, as well as in actual experience outside the college.

Candidates for membership in the graduate school who do not desire to work for a degree may, with the approval of the director of the school, take more than one subject in the same department, or pursue work in several departments, if their preparation will permit. A statement of the subjects chosen must in each case be submitted to the director of the graduate school for approval by the student's advisory committee. The chosen subjects must bear an appropriate relation to each other.

A working knowledge of French and German is essential to successful graduate work, and students not having this will find it necessary to acquire it as soon as possible after entering.

The graduate staff reserves the privilege of recommending and allowing courses in other institutions as a part of residence instruction. Such supervision will be exercised and credit granted as are essential to the highest standards of efficiency.

Theses.

A thesis is required of each candidate for an advanced degree. It must be on a topic belonging to the candidate's major subject; must show that its writer possesses the ability to carry on original study; and must be an actual contribution to knowledge.

The thesis in its final form, must be submitted to the director by May 15 of the year in which the student is to present himself for the advanced degree, and before he may take the required examination. Three complete copies are required. One of the said copies is to be retained as an official copy by the said director, one is to be deposited in the college library, and the third is to be retained by the department in which the thesis was prepared. The candidate for the doctor's degree must be prepared to defend at the oral examination the views presented in his thesis.

Final Examinations.

For the degree of master of science, master of agriculture, or master of landscape architecture, final examination, which may be either written or oral, or both, is given upon the completion of each subject.

For the degrees of doctor of philosophy or doctor of agriculture, final examinations on the minors taken are given upon the completion of the subjects. In the major subject, a written examination, if successfully passed, is followed by an oral examination in the presence of the faculty of the school.

Degrees conferred.

The degrees of master of science, master of agriculture and master of landscape architecture are conferred upon graduate students who have met the following requirements: —

1. The devotion of at least one year and a half[1] to the prosecution of study in two subjects of study and research, not less than one full college year of which must be in residence. In the case of a master of landscape architecture the student must follow the prescribed course of study.

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[1] All time statements refer to minimum time.

2. The earning of not less than fifty credits in the chief or major subject, and of not less than twenty-five credits in the minor subject. Students pursuing the course in landscape architecture will devote all of their time to the established course, and meet the conditions of one year of experience outside the college.

3. The preparation of a thesis in the major subject, constituting an actual contribution to knowledge, and accompanied by drawings if necessary. The thesis may be waived for the degree of master of agriculture.

4. The passing of final examinations, in both major and minor subjects, to the satisfaction of the professors in charge.

5. The payment of all fees and college expenses required.

The degrees of doctor of philosophy and doctor of agriculture are conferred upon graduate students who have met the following requirements: —

1. The devotion of at least three years to the prosecution of three subjects of study and research in residence at the college.

2. The earning of not less than one hundred credits in the chief or major subject, and of not less than twenty-five credits in each of two minor subjects.

3. The preparation of a thesis, in the major subject, constituting an actual contribution to knowledge and accompanied by drawings if necessary. For the degree of doctor of agriculture the thesis may be modified to meet professional requirements.

4. The passing of final examinations, in both the major and minor subjects, to the satisfaction of the instructors in charge.

5. The payment of all fees and college expenses required.

The fee for the degree of master of science, master of agriculture, or master of landscape architecture is $10, and for the degree of doctor of philosophy or doctor of agriculture, $25.

Courses offered.

Courses available as major subjects for the degree of doctor of philosophy: —

Agricultural economics
Botany.
Chemistry.
Entomology.
Horticulture.
Microbiology.
Rural sociology.

Courses available as major subjects for the degree of master of science: —

Agricultural economics.
Agricultural education.
Agriculture.
Agronomy.
Animal husbandry.
Botany.
Chemistry.
Entomology.
Horticulture.
Mathematics and physics.
Microbiology.
Poultry science.
Rural sociology.
Veterinary science.

Courses available as major subjects for the degree of master of agriculture: —

Agronomy.
Animal husbandry.
Poultry science.

The course in landscape architecture leads to the degree of master of landscape architecture.

Courses available as minor subjects for the degree of doctor of philosophy: —

- Agricultural economics.
- Agricultural education.
- Agriculture.
- Agronomy.
- Animal husbandry.
- Animal pathology.
- Botany.
- Chemistry.
- Entomology.
- Horticulture.
- Landscape architecture.
- Microbiology.
- Poultry science.
- Rural sociology.
- Zoölogy.

Courses available as minor subjects for the degree of master of science: —

- Agricultural economics.
- Agricultural education.
- Agriculture.
- Agronomy.
- Animal husbandry.
- Animal pathology.
- Botany.
- Chemistry.
- Entomology.
- Horticulture.
- Landscape architecture.
- Mathematics and physics.
- Microbiology.
- Poultry science.
- Rural sociology.
- Veterinary science.
- Zoölogy.

General Outline of Courses for Advanced Degrees.

Agricultural Economics (Major Course). — 1. Graduate research work in agricultural economics will be developed by four principal methods, namely, historical, statistical, accounting and general field investigation. In all instances the method includes facility in investigation, tabulation and interpretation of results.

2. Candidates for the doctorate, the master's degree, or candidates offering a minor in agricultural economics, will be required to pass an examination covering the undergraduate work now offered in agricultural economics, including Course 50, the elements of economics, Course 75, the agricultural market and Course 52, co-operation in agriculture; and in addition such definite research work as may be outlined by the department, to consist of original investigations in some particular divisions of the subject of agricultural economics. Courses 52, 75, 76 and 77 are for graduates and undergraduates. Special investigations may be made by electing seminars in agricultural economics.

3. Candidates for the doctor's degree will be required to write a thesis, and candidates for the master's degree a thesis or a report, covering results of a specific line of personal investigation in one or more fields of the subject. Each candidate will also be required to have a working knowledge of the general field of economics, the theory of agricultural economics, the problems of agricultural production, land tenure, land problems, agricultural commerce, agricultural co-operation, agricultural credit, statistics of agriculture and prices, and markets and marketing.

Agricultural Education (Major Course). — Courses are available in agricultural education as major or minor subjects for the degree of master of science, or, as a minor subject, for the degree of doctor of philosophy. Study will be pursued along one or several of the following lines: —

1. Massachusetts school legislation.
2. Origin and growth of primary, secondary and higher education in Massachusetts.

3. The origin and growth of normal schools, industrial schools and agricultural schools.

4. Educational literature, fiction, periodicals and reports.

5. The physical and mental development of the individual.

6. School administration.

Agronomy (Master of Science). — This course is developed in two directions, depending on whether the candidate is preparing for investigational work or for teaching. In the former case more attention is paid to methods of investigation; in the latter, to interpretation of results. The student may specialize in either Part I. or Part II. of the following: —

I. *Soil Fertility.* — (*a*) The humus problem: Effect of different cropping systems on the humus content of the soil; cultivation, drainage and liming in their effect on soil humus; increase by green manure crops; use of animal manures as sources of humus; conservation of organic matter.

(*b*) The nitrogen question: Losses of nitrogen as occasioned by cropping systems, tillage methods and soil treatment; gain of nitrogen through legumes and other agencies; commercial nitrogen, physiological effect upon the plant, comparison of different forms both in regard to their ultimate as well as immediate effect, amount of application from the business standpoint.

(*c*) Mineral elements of plant food: As above for nitrogen.

(*d*) Lime: Causes of "soil acidity;" comparison of forms of lime; ultimate effect of lime on soil fertility; cost *versus* returns from use of lime.

(*e*) Crop adaptability.

II. *Field Crops.* — (*a*) Distribution, as governed by soil fertility; climatic influences; economic conditions.

(*b*) Kinds and varieties.

(*c*) Cultural methods.

(*d*) Breeding: A knowledge of the principles of breeding is presupposed. With this as a basis, a study of methods, practices and results, as applied to a given crop, must be made.

III. *Thesis.* — The thesis may be taken either in soil fertility or in crop production. In either case a problem for original investigation must be formulated by the candidate, the line of attack developed, the work carried through and results presented in acceptable form.

Literature. — It is required that the candidate familiarize himself with the available literature of the various topics studied.

Animal Husbandry (Master of Science). — *Course A. Animal Breeding.* — 1. Reading: Thorough survey of the scientific works dealing with plant and animal breeding and improvement.

2. Project: Each student must outline and pursue some Mendelian problem.

3. Thesis: This is to be a complete treatise of the problem which the student undertakes; it should be a valuable contribution to the present knowledge of the question of animal breeding.

Course B. Animal Nutrition. — This course is in outline similar to A. It is designed to cover the field of nutrition, feeding and management of live stock.

Seminar: Regular periods will be devoted to a discussion of the projects undertaken, together with criticisms of the available material on the question pursued.

Object. — To give the student a comprehensive knowledge of feeding, breeding and management of live stock. This may be divided into a major and a minor, in order to give the student the opportunity of devoting a proportionate share of his time to the class of live stock in which he is particularly interested.

Reading. — The student is to make a very complete survey of experimental and periodical literature dealing with the various phases of the subject.

Practice. — Before the completion of the work for the degree, the student must have the equivalent of at least one year's continuous work on an approved live-stock farm.

Seminar: Regular periods to discuss progress of the work.

ANIMAL PATHOLOGY (Minor Course only). — 1. Reviews in anatomy.

2. Reviews in organography and histology.

3. Special lectures and readings in general and special pathology.

4. Laboratory studies in general and special pathology.

5. Pathological technique.

6. Conferences.

BOTANY (Major Courses). — The equivalent of certain undergraduate courses, determined in the case of each student by the department, is prerequisite. Candidates for the degree of master of science are required to pass a final examination in writing. A final examination in writing before the department and an oral examination before the graduate staff must be passed by candidates for the degree of doctor of philosophy. Candidates for the latter degree are required to attend all graduate lectures given by the department. Candidates for the degree of master of science will take those lectures given during their period of study in the department. All lecture courses will be given in rotation, except courses (*a*) and (*b*), which will come every year. There will be three lectures a week throughout the fall, winter and spring terms. These lecture courses, outlined below, are designed to cover a period of three years.

(*a*) *Plant Physiology.* — The lectures will consider, under the nutrition of the plant: its chemical structure, absorption of various nutrient substances and their changes in the plant, assimilation and dissimilation of carbon and nitrogen by autotrophic and heterotrophic plants; under changes in the form of plants: growth and form under constant external factors, the influence of variable external and inner factors on growth, form and development; and under plant movements: the various tropisms, nutations, etc. Supplemental demonstrations, laboratory work and readings in the standard texts and journals. One lecture a week for 36 weeks.

(*b*) *Plant Pathology.* — A general consideration of the history, nature and causes of plant disease; parasitism, predisposition, immunity, degeneration, natural and artificial infection, dissemination, epidemics, biologic strains, monstrosities and malformations, proliferation, prevention and control, economics of plant diseases. One lecture a week for 36 weeks.

(*c*) *Normal and Pathogenic Metabolism.* — The lectures in this subject embrace, in more or less detail, comparative consideration of the metabolism of the host in health and disease; the metabolism of the parasite under varying conditions; enzyme activities in host and parasite; methods of preparation and determination of enzyme activities; chemical and physical changes induced in plant tissue by parasites; immunity, etc. Current investigations and new phases of the subjects under discussion will also receive attention as they appear. One hour a week for 24 weeks.

(*d*) *Plant Evolution.* — Consideration of plant life in its inception; differentiation; origin and evolution of sexual and asexual reproduction; variation;

heredity and adaptation; phylogenetic relationships. One lecture a week for 24 weeks.

(*e*) *Biologic Relations.* — Consideration of certain phases of the morphological and physiological adaptations of plants with regard to insect visit; the rôle of thorns, hairs, tendrils, glands, etc. Various experiments will be made to test out experimentally some of the existing theories concerning biologic adaptations. One lecture a week for 12 weeks.

(*f*) *The Ecology of Plants.* — This course deals with the water, light and temperature relations of plants, and the various adaptations in response to these factors; the various types of plant formation; the migration of plants; the competition of plants; invasion and successions of plants under varied conditions; and the various types of alternations and zonations. One lecture a week for 12 weeks.

(*g*) *Physiological Plant Pathology.* — This course considers those plant diseases not due to bacterial or fungous parasites, but resulting from unfavorable physical or chemical conditions of the soil; from harmful atmospheric influences, such as too dry air, too much moisture, hail, wind, lightning, frost; from injurious gases and liquids; from lack of or too much light; from wounds. A knowledge of the normal physiology of the plant is required. Demonstrations and laboratory work will be given, together with assigned readings. One lecture a week for 12 weeks.

(*h*) *History of Botany.* — A historical survey of the science; history of certain culture plants, such as wheat, corn, coffee, potato, rice, and their influence on civilization. One lecture a week for 18 weeks.

Seminar: A weekly seminar for members of the department staff, graduate students and major senior students is held, at which important current botanical papers are discussed. Attendance and participation are required.

Collateral Reading: Extensive reading of botanical literature in English, German and French, designed to give the student a broad knowledge of the science, is required of all major students. Final examinations are based in part upon this reading course.

Thesis: Each major student is required to select a problem in plant pathology or physiology (in other branches at the discretion of the department) for original investigation, and the thesis must embody a distinct contribution to knowledge. An effort will be made to assign problems having some bearing on scientific and economic agriculture.

Minor Course. — For a minor a student may take such of the work offered by the department as seems best suited to his major course. In most cases no problem will be assigned.

Professor OSMUN, Dr. CHAPMAN, Associate Professor ANDERSON and Assistant Professor CLARK.

CHEMISTRY. — I. Major courses for the degree of master of science. Students will be required to take Courses 101, 108 to 114. In addition to this the requirements in the various thesis subjects are: —

Organic and Bio-Chemistry. — Courses 115 and either 105, 106 or 107, and 6 hours for one term selected from Courses 103 (*b*) and (*f*), and 104.

Analytical and Industrial Agricultural Chemistry. — Courses 116, 103 (6 hours), and 6 hours for one term selected from Courses 102, 104 to 107.

Physical Chemistry. — Courses 104, 117, and 6 hours for one term selected from Courses 102, 103, 105 to 107.

Agricultural Chemistry. — Courses 103 (6 hours), 118, and 6 hours for one term selected from Courses 102, 104 to 107.

The candidate must pass a final written and oral examination before the Department of Chemistry upon undergraduate Courses 1 to 80, inclusive, and upon all graduate work taken in chemistry by him.

II. Major course for the degree of doctor of philosophy. Students will be required to take Courses 101 to 114, and one course selected from 115 to 118. In addition, the student may be required to spend at least two terms or one semester at some other recognized institution pursuing graduate work in chemistry. The candidate must pass a final written examination before the Department of Chemistry, and an oral examination before the graduate staff, upon the whole field of chemistry, and must be especially well prepared in the lines of work covered by his research.

III. Minor course for the degrees of master of science and doctor of philosophy. Students will be required to take work totaling 54 to 78 hours. This may be selected from any of the undergraduate Courses 27 and 51 to 80, or any of the graduate courses for which the student is prepared. In addition, the candidate must pass a final written and oral examination before the Department of Chemistry upon the courses taken and upon undergraduate Courses 27 and 51 to 80.

The following is a list of the courses: —

101. *Inorganic Preparations.* — Laboratory. The preparation of chemical products from raw materials. The manufacture and testing of pure chemicals. The laboratory work is essentially synthetic in nature, and is designed to aid in acquiring a more adequate knowledge of inorganic chemistry than is to be obtained by chemical analysis alone. Ten to fifteen of the preparations given in Biltz's "Laboratory Methods of Inorganic Preparations" will be made by each student. Any term, 6 hours. Professor ANDERSON.[1]

102. *Advanced Inorganic Preparations.* — Laboratory. Continuation of Course 101. Any term, 6 hours. Professor ANDERSON.

103. *Advanced Analytical Chemistry.* — Laboratory. This course may be taken in part as follows: (*a*) electrolytic analysis, 6 hours; (*b*) ultimate analysis, 6 hours; (*c*) special analytical work to meet the needs of the individual student, 6 hours. In addition, parts of undergraduate Courses 61, 62, 76 and 77 may be taken, as follows: (*d*) fertilizers, 6 hours; (*e*) insecticides, 6 hours; (*f*) milk and butter, 6 hours. (*a*), (*b*), (*c*) may be taken any time; (*d*), (*e*), (*f*) must be taken at the time the undergraduate course is given.

Professor WELLINGTON and Professor PETERS.

104. *Advanced Physical Chemistry.* — Laboratory. Measurement of the electrical conductivity of solutions; degree of ionization; ionization constants; per cent. hydrolysis of aniline hydrochloride from conductivity measurements; solubility product by the conductivity method; velocity of saponification by conductivity; neutralization point by conductivity; vapor pressure determinations; critical temperature of carbon dioxide or sulphur dioxide; transport numbers; preparation and properties of colloidal solutions; transition points by dilatometric method; heat of solution of ammonium chloride and potassium nitrate; adsorption of iodine by charcoal; splitting of racemic glycerinic

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[1] On leave of absence, 1917–18.

or racemic tartaric acids into their optical components. To each student separate work will be assigned. Any term, 6 hours. Professor ANDERSON.

105. *Advanced Organic Preparations.* — Laboratory. The preparation of compounds not included in Courses 51 and 52, such as the Kolbe synthesis of salicylic acid; benzophenone and Beckmann's rearrangement; rosaniline, malachite green, congo red, indigo and other dyes; synthesis of fructose; Grignard reaction. Barnett, Cain and Thorpe, Gatterman, Noyes, Fischer and other laboratory guides are used. To each student separate work will be assigned. Any term, 6 hours. Professor CHAMBERLAIN.

106. *Advanced Bio-Chemistry.* — Laboratory. The hydrolysis of proteins and isolation of the amino acids; the study of milk, blood and urine; dietary and digestion studies. References: Abderhalden, Plimmer, Salkowski, Hawk, etc. To each student separate work will be assigned. Any term, 6 hours. Professor CHAMBERLAIN.

107. *Industrial Organic Chemistry.* — Laboratory. The preparation, on a large scale, of wood alcohol, acetic acid, ethyl alcohol, benzene and cellulose products, such as mercerized cotton and artificial silk. References: Molinari, Rodgers and Aubert, Thorpe, Enzyklopädie der tech. Chemie, etc. To each student separate work will be assigned. Any term, 6 hours. Professor CHAMBERLAIN.

108. *Theoretical Chemistry.* — Lectures. The following topics are considered: the compressibility of the atoms; the structure of atoms; the electron conception of valence. First term, 1 hour. Given in 1917–18. Alternates with Course 109. Professor PETERS.

109. *Analytical Chemistry.* — A general survey of methods and technique covering processes commonly carried out in the laboratory. Gooch's Quantitative Analysis is used as a text. First term, 1 hour. Given in 1916–17. Alternates with Course 108. Professor PETERS.

110. *Organic Chemistry.* — Lectures. Some of the following topics will be considered both theoretically and industrially: alkaloids, synthetic dyes, essential oils, terpenes, rubber, etc.; the study of methods for carrying out general reactions; isomerism, tautomerism, condensation, etc. References, Cain & Thorpe, Cohen, chemical monographs, Lassar-Cohn, Heinrichs, Molinari. Second term, 1 hour. Given in 1916–17. Alternates with Course 111. Professor CHAMBERLAIN.

111. *Bio-Chemistry.* — Lectures. Some of the following topics will be considered both chemically and physiologically: fats, cholesterol, lecithin, carbohydrates, amino acids, proteins, urea, uric acid, purine bases, enzymes, fermentation, animal food and nutrition, photosynthesis. References, Monographs on Bio-Chemistry, Abderhalden, Plimmer, Haas & Hill, Lewkowitsch, Fischer, Euler, Mathews, Czapek. Second term, 1 hour. Given in 1917–18. Alternates with Course 110. Professor CHAMBERLAIN.

112. *Theoretical and Physical Chemistry.* — Lectures. The relation between the constitution and properties of compounds; mutarotation; steric hin-

drances; stereoisomerism of other elements than carbon; molecular association; similarity between the compounds of silicon and carbon. Third term, 1 hour. Given in 1917–18. Alternates with Course 113.
Professor ANDERSON.

113. *Theoretical and Physical Chemistry.* — Lectures. Radioactivity; the application of physical chemistry to industrial chemistry. Third term, 1 hour. Given in 1916–17. Alternates with 112. Professor ANDERSON.

114. *Seminar.* — Conferences, reports or lectures. Three terms, twice a month, 1½ hours. Professor LINDSEY.

115. *Research in Organic and Bio-Chemistry.* — Three terms. A minimum of 20 hours' laboratory work per week. Credit determined by amount of work done. Professor CHAMBERLAIN.

116. *Research in Analytical or Agricultural Industrial Chemistry.* — Three terms. A minimum of 20 hours' laboratory work per week. Credit determined by the amount of work done.
Professor WELLINGTON and Professor PETERS.

117. *Research in Physical Chemistry.* — Three terms. A minimum of 20 hours' laboratory work per week. Credit determined by amount of work done.
Professor ANDERSON.

118. *Research in Agricultural Chemistry.* — Three terms. A minimum of 20 hours' laboratory work per week. Credit determined by amount of work done. Professor LINDSEY and EXPERIMENT STATION ASSOCIATES.

ENTOMOLOGY (Major Courses, Ph.D. degree). — 1. *Morphology.* — Lectures on all, and laboratory work on a portion of the following subjects: embryology and polyembryology; transformations; histology; phylogeny; hermaphroditism; hybrids; parthenogenesis; pedogenesis; heterogamy; chemistry of colors; coloration; luminosity; deformities; variation.

2. *Ecology.* — Lectures and laboratory work as above on the following subjects: dimorphism; polymorphism; protective devices; mimicry; psychoses; insect architecture; plant fertilization; insect products; geographical distribution; methods of distribution; migration; geological history; insects and disease; enemies of insects, vegetable and animal;. duration of life; experimental entomology.

3. *Economic.* — Lectures and laboratory work as above on the following subjects: special methods of control; insecticides; special research; insect photography; methods of preparing illustrations; field work and life-history investigations; insect legislation; methods of record keeping.

4. *Systematic.* — Lectures and laboratory work as above on the following subjects: history of entomology; classifications and principles of classification; nomenclature and its rules; how to find and use literature; preparing indices; number of insects known and in existence; lives of prominent entomologists; methods of collecting, preparing, preserving and shipping insects; important collections; location of types.

5. Seminar; required readings; thesis.

All of these five courses are required of students taking a Ph.D. in entomology.

Minor Courses. — Such portions of the major courses as are most closely correlated with the other lines of work taken by the student and which can be completed in the time available.

Professor FERNALD, Professor CRAMPTON and Dr. REGAN.

HORTICULTURE. — Graduate work is offered in various lines of horticulture. For the most part this is divided into the different departments which now constitute the college Division of Horticulture, as follows: pomology, floriculture, landscape gardening, forestry and market gardening. For work in these lines application should be made direct to the heads of the several departments.

Besides this work, however, opportunity is offered for graduate study in general horticulture, including topics from the several organized departments mentioned, and also questions relating to plant breeding, general evolution, propagation, manufacture of horticultural products, etc. This general work is under the direction of Prof. F. A. Waugh, head of the Division of Horticulture.

LANDSCAPE ARCHITECTURE (Major Course). — Every student before receiving his master's degree in landscape gardening must have given some thorough and fruitful study to each of the following five departments. As far as possible these studies must be of a practical nature, *i.e.*, they must be made upon actual projects in progress of development.

1. *Theory.* — The principles of esthetics as applied to landscape gardening.

2. *Design.* — The principles of pure design and their application in landscape and garden planning.

3. *Construction.* — The practical methods of carrying out landscape plans, laying out, equipment, organization of working force, time and cost keeping, etc.

4. *Maintenance.* — Methods, organization, cost.

5. *Practice.* — Office work, drafting, estimating, reporting, charges, accounting.

Qualifications. — Each student before he may receive the master's degree with a major in this department must convince his instructors that he has a genuine aptitude for some branch of landscape gardening, either in design, construction or management.

The minimum period of graduate study will be one and one-half years. At least one year of this time must be spent in residence at the college, and also one year must be spent in practice outside the college. The work done outside the college may be prescribed by the department, and must be fully reported to the department in writing. It is essential, further, that the candidate secure the written approval of his employers outside the college. The department may, at its discretion, require a longer period of study at the college or a longer apprenticeship outside the college.

Thesis or Project. — Each student before receiving the master's degree with a major in landscape gardening must present a satisfactory thesis or complete project. A thesis will consist of a careful original study of some problem in landscape architecture, presented in typewritten form with any necessary illustrations, such as photographs, diagrams, drawings, etc. A project will consist of a completed set of studies of some suitable landscape-gardening problem, such as the design of a park, a real estate subdivision, an extensive playground. Such a project will usually consist of —

(*a*) Original surveys, including topography.
(*b*) Block plans, showing original design.
(*c*) A rendered plan or plans of the main features.
(*d*) Detailed working drawings.
(*e*) Estimates of cost.
(*f*) Complete report and letter of transmittal.

Minor Course. — Any student electing a minor in landscape gardening will be directed to take such courses from the regular catalogue list as may seem most suitable for him. Under ordinary circumstances no other work will be given to students electing minors. In special cases, however, individual problems will be assigned and individual instruction given. These exceptions will be made in cases where, by so doing, it is possible to give the student material assistance in the plan of his major work.

Prerequisite Work. — The undergraduate courses in the college known as Landscape Gardening 50, 51, 52 and 53, Drawing 25, 26, 27, Horticulture 27, 50, 51, and Mathematics 26 and 27 will be considered prerequisite to graduate work, and any student not having passed these courses or their equivalent will be required to make up such work without graduate credit. Courses known as Landscape Gardening 75, 76, 77, 78 and 79 are required and may or may not be accepted for graduate credit, at the discretion of the department.

MICROBIOLOGY. — I. *Courses leading to the Degree of Doctor of Philosophy.* — 1. The candidate must present twenty-five credits from the undergraduate study as furnished in undergraduate Courses 50, 51, 52, 80, 81 or an equivalent before he can enter upon graduate study.

NOTE. — Twenty-five credits are required of undergraduates majoring in microbiology.

2. The candidate must pursue successfully the following special courses or their equivalent. These courses are designed to give a comprehensive survey of the fields indicated, and are arranged especially for graduate students.

175. Agricultural microbiology,	5 credits.
176. Agricultural microbiology,	5 credits.
182. Dairy microbiology,	5 credits.
183. Food microbiology,	5 credits.

NOTE. — Courses 175, 176, 180, 181, 182, 183 correspond in subject-matter with Courses 75, 76, 80, 81, 82, 83 of undergraduate study; the latter courses are elementary in nature, while the former are arranged for intensive advanced study of graduate character. Candidates will be required not only to perform the exercises of the above courses, but will be expected to assist in teaching the elementary classes covering the same theme as a part of graduate requirements.

3. It will be necessary to complete additionally the following courses or their equivalent; open only to graduate students: —

190. I. 1917. Studies in technique, as photomicrography, laboratory equipment and manipulation.[1]
5 to 10 credits. Assistant Professor Itano.
151. II. 1918. Cytological and morphological studies and technique.[1]
5 to 10 credits. Professor Marshall and Mr. Hood.
152. III. 1919. Physiological studies.[1]
5 to 10 credits. Assistant Professor Itano.
177. II. 1919. Microbial studies in agriculture. Specific subjects.[1]
5 to 10 credits. Professor Marshall, Assistant Professor Itano and Mr. Hood.
181. II. 1920. Advanced sanitary or hygienic studies.[1]
5 to 10 credits. Professor Marshall and Assistant Professor Itano.
150. I., II., III. Lectures and study of literature.[2]
10 credits. Professor Marshall, Assistant Professor Itano and Mr. Hood.
200. I., II., III. Research.[3] (Some microbiological problem related to agriculture.)
40 to 50 credits. Professor Marshall, Assistant Professor Itano and Mr. Hood.

The thesis prepared must be satisfactory to the department, and the graduate staff and the candidate must be ready to defend it at his public examination. Further, following the presentation of the thesis, the candidate must submit to a written examination covering the entire subject by the department and a public oral examination under the auspices of the graduate staff.

II. *Courses leading to the Degree of Master of Science.* — 1. Prerequisite studies, as in the case of the degree of doctor of philosophy (I., 1).

2. Special studies as represented by courses —

175. Agricultural microbiology,	5 or 10 credits.
176. Agricultural microbiology,	5 or 10 credits.
182. Dairy microbiology,	5 or 10 credits.
183. Food microbiology,	5 or 10 credits.

3. Courses designed for graduate students only.

150. I., II., III. Lectures and study of literature.
5 credits. Professor Marshall, Assistant Professor Itano and Mr. Hood.
200. I., II., III. Research.[3] (Some microbiological problem related to agriculture.)
15 to 25 credits. Professor Marshall, Assistant Professor Itano and Mr. Hood.

The thesis submitted must be satisfactory to the department and to the graduate staff.

The candidate will be required to take a written examination and an oral examination by the department.

III. *Minor work in microbiology* may consist of Undergraduate Courses 50, 51, 52, and one other course, designed to support his major work, from among Courses 175, 180, 181, 182, 183. He will also be required to pursue Graduate Course 150 through four terms (see II., 3, 150). In case the candidate has had some of these courses he will be required to take more advanced substitute courses. A written examination over the subject-matter covered will be given at the close of the work.

Poultry Science (Major Course for the Degrees of M.S. and M.Agr.). — 1. *Reading.* — A review of the entire field of poultry literature, covering books, bulletins and special articles, is made, and a written report on one or more subjects required.

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[1] Repeated every three years.

[2] Continues over three years, once each week.

[3] Distributed as may be most beneficial for research work. Time and credit by arrangement.

2. *Seminar.* — A critical review and a criticism of the more important experiments carried on at the various stations in this and other countries; also a study of poultry conditions in foreign countries, methods of management, etc., besides a detailed study of some of the largest poultry projects in this country.

3. *Anatomy (Gross and Histological), Physiology and Surgery.* — This course requires a careful study of the anatomy and physiology of the fowl. Special attention is given to a study of those structures concerned with practical poultry problems. Instruction in surgical technique, adapted to fowls, may also be given.

4. *Breeding.* — The student will carry on such breeding experiments as time and facilities permit. He may also do work in connection with our regular experimental projects. A detailed study of the pertinent literature will be required. Animal Husbandry 5, or its equivalent, is a prerequisite.

5. *Feeding.* — A study of the relation of various foods and other substances to the morphology and physiology of the bird, with special reference to such subjects as egg production, feather form and structure, condition of flesh, bone, etc.

6. *Brooding.* — Studies will be made upon the relation between viability and rate of growth and the following topics: type of brooder, number of chicks in brood, ventilation, humidity, sanitation, exercise and weather conditions; also a comparison of natural methods with artificial methods of rearing chicks.

7. *Incubation and Embryology.* — A number of problems of a practical, scientific and mechanical nature relating to incubation are considered. The work in embryology is of an advanced nature dealing with its relation to morphogenesis and heredity, and presupposes an elementary knowledge of the embryology of the chick.

8. *Poultry Diseases and Sanitation.* — In this course a study is made of various problems in poultry sanitation, with particular reference to methods relating to the control and eradication of disease.

9. *Thesis.* — A thesis based on first-hand work on some problem in poultry biology or husbandry is required of all students working for the M.S. degree, and may be required of those working for the M.Agr. degree.

NOTE 1. — The postgraduate course presupposes all undergraduate work or its equivalent, together with practical experience. Without the latter, students will be unable to handle Courses 5, 6 and 7. At the discretion of the instructor in charge, graduate students may be required to pursue undergraduate courses in other departments without credit.

NOTE 2. — Practical poultry work may be required, but no credit will be given for such work.

NOTE 3. — Courses 1 and 2 are designed particularly for minors.

RURAL SOCIOLOGY. — Courses are offered in Rural Sociology as major or minor subjects for the degree of doctor of philosophy.

Candidates for the master's degree will be required to pass an examination in all courses offered by this department primarily for undergraduates, as shown in the departmental classification. In addition they will be required to select one or more of the divisions of the subject for intensive study and research, as indicated below.

A thesis showing the results of personal investigation on some particular topic or topics must be presented. The thesis must show familiarity with the material bearing on the subject, ability in discovering and utilizing original sources, judgment in evaluating facts, evidences and authorities, originality and independence of thought. It must be a contribution in a very definite way to rural sociological thought.

Topics for Study and Research.

1. The rural community: —
    (*a*) Historical development.
    (*b*) Influence of modern conditions on family and community life.
    (*c*) Problems and methods in community organization.
    (*d*) Community planning in Massachusetts.
2. Origin and development of rural institutions: —
    (*a*) Scope, function and influence of educational institutions on rural social progress. Plans for betterment.
    (*b*) History of the development of the rural church, its problems and program for improvement.
    (*c*) The farm family, in its relation to religious, cultural, educational and social agencies. The relation of the standard of living to rural social progress.
3. Rural organization: —
    (*a*) The scope and function of rural organization in development of rural life.
    (*b*) Work of the national government in rural organization.
    (*c*) County and institutional work in rural organization.
    (*d*) Leadership in its relation to organization.
4. Rural government and rural law: —
    (*a*) Development of rural local government in New England and the west. Progress in efficient local self-government.
    (*b*) Relation of the State to the farmer, influence of the farmer in legislation, the organized ways and means by which the State aids the farmer directly.
    (*c*) Work of the national government in its relation to the social welfare of the farming people.
    (*d*) Agrarian legislation in the United States and Europe affecting rural social welfare.
5. Farmers' organizations: —
    (*a*) Social problems underlying farmers' organizations in reference to service and permanency.
    (*b*) Principles of organization.
    (*c*) History of farmers' organizations in the United States.
6. Rural social and sociological surveys: —
    (*a*) An intensive study of the place and function of statistical data in the sociological field, its evaluation and interpretation.
    (*b*) A critical study of social surveys of rural life and methods of survey, with a view to discovering the strength and weakness of each.
7. Social condition of the rural people: —
    (*a*) Origin and development of rural ideals.
    (*b*) The status of the rural people in relation to health, morality, crime, etc.
    (*c*) Problems of social psychology arising in rural life.

The course required for candidates offering a minor will be arranged after a conference with the director of the department, and will take into consideration the needs of the student in view of his previous preparation. The amount of time required of the student for his minor work will correspond with the requirements of the graduate school.

VETERINARY SCIENCE. — Work is available in anatomy, hygiene, veterinary pathology, medicine, surgery, parasitology and other special lines or divisions of the subject.

ZOÖLOGY. — Courses in zoölogy may be available as a minor for the degree of master of science and as a minor for the degree of doctor of philosophy. The nature of the work will necessarily vary according to circumstances, and may be intensive in a special field and correlated closely with the major work of the student, or it may be of a more general character, depending on the student's needs or previous acquaintance with general zoölogical science. The time devoted to zoölogy as a minor for either of the above-named degrees may vary from 12 to 16 hours per week, pursued for a year and a half.

List of Students.

A list of the degrees conferred in the Graduate School, and of the students enrolled, is given in the general lists at the end of the volume.

THE SHORT COURSES

AND

THE EXTENSION SERVICE.

THE SHORT COURSES.

The short courses offered by the Massachusetts Agricultural College are designed to meet the needs of those who cannot come to the college for the regular agricultural courses. They furnish the student with instruction in modern accepted methods, and are designed to help the farmer and the housewife meet the present economic conditions. In the main, the instruction is given by the regular teaching force of the college, the same laboratories and equipment being used as in the regular college work. The short courses may be grouped as follows: —

A. Winter Schools.
  1. Ten Weeks' Course.
  2. Spring Beekeeping School.
  3. Apple Packing School.
B. Summer Schools.
  1. Summer School of Agriculture and Country Life.
  2. School for Rural Social Service.
  3. School for Library Workers.
  4. Boys' and Girls' Agricultural Camps.

EXPENSES OF THE SHORT COURSES. — The expense of attending any of the short courses is approximately as follows: —

Registration fee (Ten Weeks' Course, Apple Packing and Summer School),	$5
Furnished rooms in private houses (per week),	$2 to $4
Board at college dining hall (per week),	$6 to $6.50
Board with private families (per week),	$7 to $8

A lunch counter is operated in connection with the dining hall; meals may be obtained there *à la carte* at very reasonable rates.

Students in each of the dairy courses must provide themselves with two white wash suits and caps for use in the practical dairy work. The cost in Amherst is about $1.25 for suit and cap.

REQUIREMENTS FOR ADMISSION TO SHORT COURSES. — No entrance examinations are required, but students are advised to review their school work in English and arithmetic. Practical experience in farm, garden, orchard or greenhouse work is an advantage. The courses are open to both men and women.

Students must be at least eighteen years of age, and must furnish satisfactory evidence of good moral character. References are required, and these are investigated before applicants are accepted.

A. WINTER SCHOOLS, 1918.

1. OUTLINE OF THE TEN WEEKS' COURSES, DECEMBER 31 TO MARCH 9. — The following courses are offered: —

1. Soil Fertility. Professor BEAUMONT. Three lectures a week.
2. Field Crops. Professor JONES. Two lectures and one two-hour laboratory period a week.

3. Type and Breeds of Live Stock. Professor McNutt. Three lectures and two two-hour judging periods a week.

4. Live Stock Feeding. Professor McNutt. Three lectures a week.

5. Animal Breeding. Professor McNutt. One lecture and one two-hour laboratory period a week.

6. Dairying. Professors Lockwood and Jamison. Five lectures and five two-hour laboratory periods a week.

7. Dairy Bacteriology. Professor Marshall. Two lectures a week, one two-hour laboratory period a week.

8. Animal Diseases and Stable Sanitation. Professor Paige. Two lectures a week.

9. Poultry Husbandry. Professors Graham and Payne. Five lectures and one two-hour laboratory period a week.

10. Farm Management. Mr. Peacock. Two lectures a week.

11. Farm Accounts. Mr. Peacock. Two two-hour laboratory periods a week.

12. Fruit Growing. Professor Sears. Three lectures and one two-hour laboratory period a week.

13. Market Gardening. Professor A. S. Thomson. Three lectures and two two-hour laboratory periods a week.

14. Landscape Gardening. Professor Harrison. Two two-hour laboratory periods a week.

15. Rural Improvement. Professor Waugh. Two lectures a week.

16. Floriculture. Professor Hecht. Five lectures a week and field trip.

17. Forestry. Professor Clark. Two lectures a week.

18. Botany. Professor Anderson. Two lectures a week.

19. Entomology. Dr. Regan. Three lectures a week.

20. Beekeeping. Professor Gates and Mr. Byard. Two lectures and one two-hour laboratory period a week.

21. Farm Mechanics. Professor Gunness. One lecture and two two-hour laboratory periods a week.

22. Rural Sanitary Science. Professor Marshall. Two lectures a week.

23. Problems of Marketing and Distribution. Professors Cance, Damon and Wilkinson. Two lectures a week.

24. Junior Club Work. Professor Farley. Two lectures a week.

25. Foods and Conservation. Mrs. Smith. Three lectures and two two-hour laboratory periods a week.

2. Spring Beekeeping School. — This itinerant school is held in Amherst once in three years, and extension schools are planned for different sections of the State during the intervening years. It is an intensive course, primarily for a limited number of practical beekeepers. The course, conducted by a strong staff of specialists, occupies seven hours daily for two weeks (Saturdays being devoted to excursion), and comprises lectures, laboratory practicums and field excursions. As this school was held at the college in 1916, it will be located in some other section of the State in 1918. Announcement of date and place will be made later. The course is under the direction of Burton N. Gates, associate professor of beekeeping.

3. Apple Packing School. — The work of this school, which is conducted by the Department of Pomology, is of a practical nature, and includes both box and barrel packing. Persons taking the course will become familiar with the various types of packs, and will receive sufficient practice to enable them to do good commercial packing. The 1918 school will probably be held in November, on dates to be announced.

B. Summer Schools, 1918.

1. The Summer School of Agriculture and Country Life. — The Summer School of Agriculture and Country Life of the Massachusetts Agricultural College will open July 1, 1918, for a term of four weeks. This will be the eleventh session of this Summer School, those of past years having been

highly successful. The experience of past years will aid in making material improvements in the session of 1918.

The work of the Summer School was designed originally for school teachers, and the attendance has been largely of that class. Special attention will be given to the needs of teachers again in 1918. It has been found, however, that there are many persons who seek a general knowledge of theoretical and practical agriculture, and who can come to the college conveniently during the summer season. Practical courses will be offered for the benefit of such persons also.

1. Soil Fertility. Professor Jones. Five exercises a week.
2. Breeds and Livestock Judging. Professor McNutt. Five exercises a week.
3. Poultry Breeding and Management. Professor Payne. Four lectures and 1 laboratory period a week.
4. Dairying. Professor Jamison. Three lectures and two two-hour laboratory periods a week.
5. Fruit Growing. Professor Sears. Five exercises a week.
6. Vegetable Gardening. Professor Thomson. Five exercises a week.
7. Home and School Garden Supervision. Professor Hart. Three two-hour periods a week.
8. Boys' and Girls' Club Work. Professor Farley. A series of conferences.
9. Amateur Home and Flower Garden. Professor Hecht. Three lectures and two two-hour demonstration periods.
10. Trees and Shrubs. Professor Thompson. Five exercises a week.
11. Bird Life. Mr. Maynard. Five exercises a week.
12. Insect Life. Dr. Regan. Five exercises a week.
13. Plant Diseases. Professor Osmun. Five lectures a week first two weeks.
14. Beekeeping. Professor Gates. Five lectures a week last two weeks.
15. Food Conservation. Professor Chenoweth. Two lectures and three two-hour laboratory periods a week first two weeks.
16. Foods. Mrs. Smith. Three lectures and two demonstrations a week last two weeks.
17. Household Management. Mrs. Smith. Two hours a week.
18. Sewing. Mrs. French. Five hours a week.
19. Designs and Practical Arts (1). Mr. Ried. Five exercises a week.
20. Practical Arts (2). Mr. Ried. Five exercises a week.
21. Elementary Agriculture. Professor Jones. Five periods a week.
22. Organized Play and Recreation. Miss Fuller. Three lectures and four demonstrations a week.
23. Plays and Pageantry. Miss Hall. Five exercises a week.
24. Conservation of Health. Professor Marshall. Ten lectures.
25. First Aid and Home Nursing. Mrs. Pomeroy. Five exercises a week last two weeks.
26. Farm Management. Professor Foord. Five lectures a week first two weeks.

In order to meet the demand brought about by the present emergency, courses will be given in the 1918 Summer School in foods, canning, drying, storing, first aid and Red Cross work. A thorough course in garden supervision will also be offered.

A course of evening lectures on popular topics relating to the work of the school is a feature of the general program. Several able lecturers are engaged for this course each year.

The expenses are low. Amherst is situated in one of the most noted historical and educational centers in the country. Any one interested in problems pertaining to country life should not fail to attend. A descriptive circular can be had April 1, 1918.

2. The School for Rural Social Service. — This year special emphasis will be laid upon the group of courses given particularly for those who might be classed as rural social workers. These courses last year were primarily for clergymen, teachers and workers with women and girls.

The courses offered presented the rural problem from several standpoints, and served to show the relationships of the workers in the different lines to their respective fields and to the larger community problems which are constantly being presented to them.

Courses offered, 1918.

Home and school gardens.
Redirection of the rural school.
Gardening and canning.
The new rural school.
Health.
Organization for women and girls.
Practical agriculture.
Co-operation and marketing.
The new rural church.
Rural community organization.

Several of the courses offered in the regular Summer School of Agriculture and Country Life are also available to those who register in the School for Rural Social Service and pay the required fees.

3. School for Library Workers. — During the summer of 1917 a very successful school for library workers, of one week's duration, was held at the college. The work was planned especially for those librarians and library assistants in village and rural libraries, whose special training and experience have necessarily been limited. This school will again be offered in July, 1918.

The faculty of the summer schools for 1917 was as follows: —

Kenyon L. Butterfield, A.M., LL.D., President of the College.
William D. Hurd, M.Agr., Director of the Extension Service and Supervisor of Short Courses.
Andrew S. Thomson, A.M., Assistant Professor of Market Gardening, in charge of Summer Schools.
Charles R. Green, B.Agr., Librarian of the College.
F. Josephine Hall, A.M., Adviser for Women.
Laura Elizabeth Bell, Director of Physical Education, Amagansett, N. Y., Physical Education.
Anna L. Brown, M.D., Secretary for Hygiene, National Board, Y. W. C. A., Physical Education.
John L. Byard, Superintendent of Apiary, Beekeeping.
Walter J. Campbell, M.A., Director of County Work, Y. M. C. A. College, Springfield, Mass., Rural Sociology.
Anna M. Clark, County Secretary, Northeastern Field Committee, National Board, Y. W. C. A., Work with Girls.
William D. Clark, A.B., M.F., Professor of Forestry, Forestry.
Laura Comstock, Extension Professor of Home Economics, Home Economics.
Ethel Cutler, Secretary for Religious Work, National Board, Y. W. C. A., Story Telling.
George L. Farley, M.Sc., Supervisor, Junior Extension Club Work, Boys' and Girls' Clubs.
Agnes Burns Ferguson, M.D., Director of Playgrounds, Pittsburg, Pa., Organized Play.
Burton N. Gates, Ph.D., Associate Professor of Beekeeping, Beekeeping.
John C. Graham, B.Sc., Professor of Poultry Husbandry, Poultry Husbandry.
Ida E. Hall, LL.B., Waltham, Mass., Plays and Pageants.
Earl Jones, M.Sc., Assistant Professor of Agronomy, Soil Fertility.
William Chauncy Langdon, Pageant Master, M. A. C. Fiftieth Celebration, Community Drama.
Charles J. Maynard, Naturalist and Lecturer, West Newton, Mass., Ornithology.
John C. McNutt, B.Sc.Agr., Professor of Animal Husbandry, Animal Husbandry.
Ezra L. Morgan, A.M., Extension Professor of Local Community Organization, Community Organization.
Helen Norris, Extension Instructor in Agricultural Education, in charge of Girls' Camp.
William S. Regan, Ph.D., Instructor in Entomology, Entomology.
Frederick W. Ried, Director of Practical Arts, Framingham (Mass.) Normal School, Handicrafts.
Marie Sayles, B.S., Extension Instructor in Home Economics, Home Economics.
Fred C. Sears, M.Sc., Professor of Pomology, Pomology.

F. A. Cushing Smith, B.Sc., M.L.A., Extension Professor of Landscape Gardening, Assistant Civic Improvement.
Robert J. Sprague, Ph.D., Professor of Economics and Sociology, Sociology.
Mabel S. Ulrich, M.D., Special Lecturer, National Board, Y. W. C. A., Physical Education.
John T. Wheeler, B.S., Assistant Professor of Horticulture, Elementary Agriculture.
James Whiting, Head Gardener, Department of Floriculture, Floriculture.

C. Miscellaneous Courses.

1. Short Courses for Special Groups. — Plans are now under way to provide short courses at Amherst, lasting four or five days, for fertilizer agents, feed agents and dealers, milk inspectors, seed dealers, bankers and other groups desiring such instruction. Information concerning these may be obtained by writing the Supervisor of Short Courses.

2. Special Days for Foreigners. — Each year there are provided at the college special days for foreigners. Instruction is given in soil management, co-operation, American citizenship and history. This work for foreigners will be arranged at the college, or in different sections of the State.

3. Meetings of Organizations at the College. — It is customary for the various State organizations of fruit growers, poultrymen, breeders and others to meet for conventions and picnics at the college. Such gatherings are welcomed by the college authorities, and organizations are cordially invited to meet in Amherst. The Extension Service will assist in arranging programs and other forms of instruction and entertainment.

All requests for announcements or further information regarding any of the short courses should be addressed to the Supervisor of Short Courses, Massachusetts Agricultural College, Amherst, Mass.

THE EXTENSION SERVICE.

The Extension Service of the Massachusetts Agricultural College is an organized effort to carry systematic and dignified instruction to the thousands of people throughout the State who are unable, owing to various reasons, to take advantage of the regular courses offered at the college. It is in reality the "carrying of the college to the people of the State." Every department of the institution, in so far as the regular teaching and research work will permit, contributes what it can to this work. There is also a regular staff of extension workers whose business it is to present the instruction of the college to individuals and various educational organizations such as extension schools, granges, Y. M. C. A.'s, churches, boards of trade, etc., throughout the State. Because of the peculiar conditions which are presented to all agricultural workers this year the rôle played by the Extension Service assumes greater proportions than ever before. A large amount of effort is given on the part of the extension workers to the war emergency work in food production and the economy of the home. Extension work may be roughly classified under the following general heads: general administration; correspondence studies; itinerant instruction, which includes lectures and lecture courses, exhibits, demonstrations and extension schools; extension work through the various departments of the college, in which the extension specialist is responsible to the head of the department for the technique of the work and to the director of the Extension Service for its accomplishment; co-operative work of various kinds with the United States Department of Agriculture; and extension work through county, district and local agents. Some of the ways in which this is being done are briefly described below.

COURSES GIVEN AT THE COLLEGE.

1. FARMERS' WEEK. — This week has become a very prominent feature of the agriculture of the State. Instruction is presented by means of lectures, demonstrations, exhibits, round tables and conferences, covering a period of five days. The regular college equipment is used, and the work of the college faculty is supplemented by lectures and demonstrations by eminent men and women from our own and other States. The 1918 program will be divided into 3 sections, as follows: —

1. Agriculture.
2. Horticulture.
3. Home Economics.

These sections take up the time from early morning until late afternoon, and in the evening there are lectures given by prominent men and women. Fruit, corn, live stock, dairy and poultry shows and other exhibits present the most recent improvements in these various lines of work that should be brought to the attention of the farmer who hopes to keep his work and equipment modern. No fee is charged.

2. Annual Beekeepers' Convention. — This convention is held during Farmer's Week. Illustrated lectures, practical demonstrations and commercial displays are important features of the convention. Meetings of State and county beekeepers' associations and of apiary inspectors also are scheduled at this time.

3. Polish Farmers' Day. — A special day is set aside in March of each year which is known as Polish Farmers' Day. There are hundreds of Polish farmers in the Connecticut valley, and this day represents a special effort on the part of the college to be of service to them. Instruction is given relative to the crops and animals in which these people are most interested, soil fertility problems, co-operation, American citizenship, Polish and American history, etc. The services of an interpreter make the day's exercises of added interest and value. It will be held on April 8 and 9, 1918.

4. Annual Conference of County Agents and Vocational Agricultural Instructors. — In December of each year a one-week conference of county agents and vocational agricultural instructors is held at the college. This is for the purpose of correlating the extension work throughout the State, and to enable the field workers to keep in up-to-the-minute touch with agricultural problems, methods and research as conducted in Massachusetts as well as other States in this particular section of the country. The next annual conference will probably be held during the third full week in December, 1918.

5. Poultry Convention. — In the preparation of our sixth annual poultry convention the wishes and needs of the poultrymen and women of the State will be the first and only consideration. It is not often that the poultry public has an opportunity to hear men of national reputation from different parts of the country, and it is such men that we secure for this occasion.

The special features of the program for 1918 will be as follows: —

1. Lectures by the best talent that can be secured.
2. Demonstrations in killing, picking, packing and preparation for retail trade.
3. Demonstrations in grading and judging market eggs.
4. Demonstrations in selection and mating both for utility and exhibition purposes.
5. Demonstrations with poultry equipment.
6. Poultry museum. Samples of feeds, equipment, diseased specimens, charts, etc.
7. A small poultry farm in Massachusetts. This will be made one of the special features of the program.

Program ready June 1. The convention will be held July 24, 25 and 26, inclusive.

6. Agricultural Camp. — During July, dates to be announced. These camps are arranged in order that boys from rural districts and small towns may receive some instruction in agriculture and clean, wholesome sports, and that they may have impressed upon them their responsibilities as coming members of society. Teachers, clergymen, Y. M. C. A. workers and county agents are especially urged to send boys who will be benefited by the instruction given at these camps.

The main purpose of these camps is fourfold: —

1. To interest the boy in agriculture and country life. This is the primary object.
2. To impress on the boy his responsibilities as a member of society.

3. To teach the boy clean, wholesome sports, recreation and proper spirit in competitive contests.

4. To demonstrate the value of a boys' camp as an educational factor.

The camps are under military discipline. Not more than forty-two boys — reservation being made for three from each county — will be taken at one time, therefore application should be made early. A succession of these camps, each lasting one week, will be arranged during July. The College feels it has a direct duty to the boys of the State whose inclinations draw them toward agricultural pursuits. In addition to instruction along agricultural lines there will be a well-balanced program of instruction in some of the vital problems of life, and periods will be devoted to athletics and other forms of recreation. The cost to each boy has, in the past, been $8 for the week. This fee helps defray the cost of maintaining the camp, meals, instruction, lectures and so forth.

The daily program consists of camp duty, flag raising, agricultural lessons, talks on hygiene and good citizenship, play and recreation, instruction in handicrafts and photography, evening camp fires, and lectures by men prominent in boys' work. The regular instructors of the college give practical talks on various agricultural specialties, these talks being followed by demonstrations and by inspection of the departmental equipment, such as the dairy, poultry plant, orchards, etc.

Features of the agricultural work are the stock-judging contests, corn-judging contests, operation of the Babcock milk test and similar specialties. The talks by the different instructors are made very practical, and the boys are given every opportunity to participate in the various lines of agriculture which are outlined.

During the past three years the third camp has been composed of the third prize winners in the State-wide boys' and girls' clubs, a separate camp being maintained upon the same general plan for the girl winners. This will undoubtedly be a feature of these camps in the future.

Opportunities are given for those interested to receive instruction under special teachers in basketry, photography, stock-judging, whittling, surveying and map reading, wireless telegraphy, wig-wagging, shop work, first aid, rope tying and splicing, seed testing, military drill, bird study, etc. Other features are the camp newspaper, minstrels and vaudeville, debates and mock trial and the camp circus.

7. Conference on Rural Organization. — This conference is held as a closing feature of the summer school each year. It takes up various problems of New England country life. Numerous State organizations co-operate with the college in providing the programs. Section meetings of various groups are held each forenoon, a general round-table discussion is held each afternoon, and lectures are delivered each evening by persons prominent in social and educational work. Many small group conferences are also arranged. This conference will follow immediately after the summer school.

Correspondence Courses. — The purpose of the correspondence courses is to furnish systematic instruction in those lines which will most benefit the general farmer, the dairyman, the fruit grower, the market gardener, the poultryman, the teacher, the homemaker, and all others who are interested in agricultural and country-life matters. It is the purpose to present up-to-date, accurate and concise information in such a manner and in such language that all who pursue the study may readily understand the work.

Courses offered. — A number of courses are in process of revision and several are being rewritten. During 1918 courses will be available as follows: —

1. Soils and Soil Fertility. Assistant Professor JONES.
2. Manures, Fertilizers and Soil Amendments. Assistant Professor JONES.
3. Field Crops. Assistant Professor JONES.
4. Farm Dairying. Professor LOCKWOOD.
5. Fruit Growing. Professor SEARS, Associate Professor CHENOWETH.
6. Market Gardening. Assistant Professor A. S. THOMSON.
9. Farm Accounts. Professor FOORD.
10. Entomology. Dr. REGAN.
12. Beekeeping. Associate Professor GATES.
13. Forestry. Professor CLARK.
14. Shade Tree Management. Professor OSMUN.
17. Poultry Husbandry. Professor GRAHAM.
18. Home Economics. Extension Professor COMSTOCK.

Methods of conducting the Work. — The best known methods of conducting correspondence course teaching are employed. Certain courses are based entirely upon text-books, others consist wholly of typewritten lectures, while others combine the two. If books are not required they are usually recommended.

The courses are designed primarily for the individual student. A new phase of the work, however, is the organization of study clubs or classes, meeting together periodically and using the courses as a basis of study. Correspondence in regard to this work is invited.

Enrollment of Correspondence Courses. — Students may enroll in the courses at any time between October 1 and June 1, and one year from the date of registration is allowed for the completion of each course. It has been found advisable to discontinue the courses through the summer months, as farmers and most other students cannot devote the necessary amount of time to the lessons during this season.

Expenses of the Correspondence Courses. — In order that none shall enroll except those who are interested and desire to pursue earnest study, a small fee is charged. This has been fixed at $2 for each course except where the courses are divided, and it has been found advisable to charge $2 for each of the parts in these instances. The fee is payable strictly in advance, at the time the enrollment card is sent. When text-books are required the student purchases these.

MISCELLANEOUS SHORT COURSES. — For certain such courses, see page 155.

LECTURES AND DEMONSTRATIONS. — The members of the faculty of the college are, when other duties will permit, available for lectures and demonstrations before granges, men's clubs, women's clubs, Y. M. C. A.'s, farmers' clubs, boards of trade and other organizations. A list of more than 40 lecturers and 200 subjects on various phases of agriculture, country life, economics, sociology, education, civic betterment and various scientific subjects has been prepared. Full courses of lectures or single lectures may be arranged.

Organizations arranging the lectures are asked to pay the traveling expenses of the lecturer, provided no admission fee is charged. When admission is charged the lecturer is entitled to a fee in addition to traveling expenses.

EXTENSION SCHOOLS. — The extension schools are of two distinct types, the first being the Agricultural Extension School, dealing with the production side of farming and with the problems of the farm home; the second is the Extension School in Community Planning, having to do with the organization and selling end of agriculture, and with instruction in the planning and carrying forward of various community activities.

It is also possible to arrange special extension schools along one particular line of work, such as fruit growing, dairying, etc.

Communities desiring an extension school make a written request, agreeing to defray all local expenses, such as the rent, heating and lighting of a suitable hall, and the board of the instructors during the school.

Agricultural Extension Schools. — The college sends a corps of instructors to a town for a five-day school of instruction. At present the following courses are offered: soil fertility, animal husbandry and dairying, fruit growing, poultry husbandry and vegetable gardening for the men, and a homemakers' course for the women. Morning and afternoon sessions only are held.

Community Planning Extension Schools. — These schools are arranged to extend over at least three days. The following courses are offered: education, agricultural organization, community program, civic improvement, farm management, town administration, public health, community recreation and homemaking. Morning, afternoon and evening sessions are held in these schools.

EDUCATIONAL EXHIBITS AT FAIRS AND OTHER SHOWS. — The college co-operates with the managers of fairs, industrial expositions, corn shows, poultry shows, fruit shows and other exhibitions by making educational exhibits.

For outside work a large tent has been provided. In this about thirty cabinets containing educational material are arranged. A corps of lecturers and demonstrators accompany the exhibit and give practical instruction daily.

For inside work a space at least 40 by 60 feet is required for this exhibit. Smaller exhibits along special lines are sent to corn, fruit and poultry shows, milk shows, child welfare exhibits, and so forth.

The managers of fairs and exhibits are required to partially meet the cost of presenting these exhibits.

EXTENSION WORK IN SPECIAL FIELDS.

EXTENSION WORK IN FRUIT GROWING. — This work includes lectures and demonstrations on laying out and planting orchards, pruning, spraying, thinning, grading, packing and marketing fruits. Demonstration orchards, new and renovation plots, are established in different sections of the State, under a co-operative agreement between the college and the owners of land. Extension schools in fruit growing and fruit grading and packing are arranged on request. Visits to farms for advisory work are made, and correspondence on orcharding subjects is invited.

EXTENSION WORK IN ANIMAL HUSBANDRY. — This work includes lectures, demonstrations and advisory assistance on subjects pertaining to cattle, horses, sheep and swine, as well as instruction in barn planning. Assistance in organizing dairy improvement associations and breeders' associations is given; stock-judging contests for boys are arranged at the leading fairs.

EXTENSION WORK IN DAIRYING. — This includes lectures and demonstrations on the handling and care of milk, cream, butter and cheese; Babcock testing, dairy utensils and dairying manufactures. Educational campaigns may be arranged in different communities, seeking to educate producers, dealers and consumers as to the production and distribution of clean, safe milk.

EXTENSION WORK IN POULTRY HUSBANDRY. — In addition to conferences at the college and visits to the plants of poultrymen, advice on general poultry management, diseases, mating, and laying out and planning buildings, this work includes co-operative work with other State and county agricultural and educational organizations, exhibits of poultry appliances at fairs and shows and other incidental phases.

EXTENSION WORK IN FARM MANAGEMENT, FIELD STUDIES AND DEMONSTRATIONS. — This is carried on co-operatively between the college and the office of farm management of the United States Department of Agriculture at Washington. It consists of a study of farm conditions and farm management problems; instruction in keeping farm accounts and growing field crops; the use of fertilizer and lime; advice as to farm equipment, buildings, and so forth.

EXTENSION WORK IN RURAL CIVIC PLANNING. — This is carried on in connection with the Department of Landscape Gardening at the college. Assistance is rendered in various rural and village improvement enterprises, such as the planting and care of shade and street trees, the planning of playgrounds, school grounds, cemeteries, picnic grounds, the beautifying of waterfronts, the rearrangement and development of town commons and reservations of historic interest, and similar activities. Efforts are made to co-operate with local granges, men's and women's clubs, village improvement societies and like organizations.

EXTENSION WORK IN HOME ECONOMICS AND FOOD CONSERVATION. — This work includes lectures and demonstrations on subjects pertaining to household economy, dietetics and the preservation of foods. Instruction is carried on by means of extension schools in rural and urban communities, and is designed both for the housewife and for leaders and supervisors.

JUNIOR EXTENSION WORK. — This is an organized effort to promote in the public schools of the State the study of agriculture and practical arts relating to country life. This is accomplished by means of conferences with school officials and school patrons, the promotion of agricultural clubs among the school children, and lectures before granges, farmers' clubs and other interested organizations. The work of the agricultural clubs is under the direction of the superintendent of schools or some one recommended by him. Each town should hold an annual exhibit of products. Exhibits representing rather extensive districts are incorporated with the various agricultural fairs in the State. In this manner elementary instruction in agriculture is promoted by the combined efforts of the public schools, of the patrons of the schools through their agricultural fairs, and of the Agricultural College, which in turn co-operates with the State Board and the United States Department of Agriculture.

EXTENSION WORK IN HOME ECONOMICS. — The Extension Service, through its home economics workers, stands ready to assist in solving problems relative to the household in the same manner as it is endeavoring through other workers to aid in working out problems of the farm. The work, among other things, includes lectures and demonstrations, assistance in forming girls' clubs and home economics clubs for women, and co-operation with existing organizations in the matter of interesting young people in the proper care of the home.

LOCAL COMMUNITY ORGANIZATION. — A number of communities in the State have appealed to the college for aid in bringing the various organizations in the community to a higher state of efficiency, in order that they themselves might take definite steps toward community development and advancement. The college is now prepared to make scientific studies of communities which lead up, by means of surveys, to the organization of local committees to study the agricultural, educational, religious, transportation, recreation and civic needs of the communities. Several State organizations and some national organizations are usually brought in to aid in working out the plans presented by these committees. Conferences on community affairs are held upon request. The college acts merely in an advisory capacity, the communities themselves doing the actual organization work.

Library Extension Work. — This consists principally of loaning to public libraries of the State general collections of 10 to 30 books and bulletins on agriculture and related subjects. Special collections of smaller size on specified subjects, such as fruit growing, dairying, poultry, beekeeping, home economics, and so forth, are also sent out. These may be kept from four to eight weeks, according to the demand for them. The only expense to local libraries is transportation charge on the books both ways. The college library also supplies, upon request, information regarding books on agriculture and related subjects.

Agricultural Surveys. — To acquire definite information as to existing conditions in rural communities, to be used as a basis for further extension work, agricultural surveys are made. The different organizations and officials in the community, such as the town officers, superintendent of schools and teachers, clergymen, librarians and others, usually co-operate in making such surveys. The survey covers all phases of community life, including soil survey, farm management practices, and the educational, social, religious and recreational life. The inventory is made upon carefully prepared blanks.

Business Co-operation and Marketing. — This work has for its object the establishment of agriculture on a better business basis. Assistance is given in organization of co-operative buying and selling associations, the securing of rural credit, the adoption of better methods of marketing, the establishment of a better market for agricultural produce, and other lines of agricultural co-operation.

County or District Agricultural Agents. — The college is co-operating with farm bureaus and improvement leagues in all the counties of the State in carrying on extension work in agriculture and home economics. Residents of the county or district may, without cost, call upon the agent for assistance upon any agricultural subject. The work is being partly supported through the co-operation of the United States Department of Agriculture, the college and the county engaging the agent.

Advisory Work with Institutions and Individuals. — Special effort is made to comply with as many of the requests of State institutions and individuals who ask for advice on farm problems as possible. The force of instructors available for this work is at present insufficient to take care of all the demands. Special trips, including visits to a number of the various State institutions, are occasionally made by a group of specialists.

Publications of the Extension Service. — In addition to the regular circulars and bulletins which announce the various short courses and lines of work mentioned, publications giving timely information on agricultural subjects are issued. Large numbers of helpful circulars and bulletins are annually distributed. A series of bulletins especially for the farm woman is one feature of this work. Reports of the work of the Extension Service, dairy record blanks, farm account blanks, boys' and girls' club circulars, lists of books, and so forth, may be had upon request.

Co-operation with Other Organizations. — The aim of the Extension Service is to co-operate with existing organizations so far as possible. It is, therefore, glad to work with local organizations, and welcomes suggestions from town officers, local granges, farmers' clubs, women's clubs, Y. M. C. A.'s, Y. W. C. A.'s, boards of trade, village improvement societies, teachers, clergymen, librarians and others interested in agriculture and country life, as to needs and methods best adapted to the meeting of these needs.

Information by Correspondence. — Besides the activities mentioned, hundreds are helped through personal visits to farms, and still larger numbers through letters of inquiry, which always receive the most careful attention from every department of the institution.

Pamphlets and bulletins are sent free to all who apply for them, and any who desire such help as has been mentioned should address the Director of the Extension Service, Massachusetts Agricultural College, Amherst, Mass.

GENERAL INFORMATION.

GENERAL INFORMATION.

A. FINANCIAL AND ADMINISTRATIVE.

Student Expenses.

TUITION.[1] — Tuition is free to residents of Massachusetts. Students who are not residents of Massachusetts are charged a tuition fee of $60 a year. The tuition charged persons not citizens of the United States is $120 a year. Students entering from Massachusetts are required to file with the president a statement signed by either town or city clerk stating that the applicant's father is a legal resident of Massachusetts; a similar statement is required of those entering from other States.

All students entering the college for the first time as undergraduates or unclassified students are charged a matriculation fee of $5, which in event of a student leaving the institution shall, if all bills due the college are paid, be remitted, or which shall upon graduation be considered as payment for the diploma.

DORMITORIES AND BOARD. — The college has dormitory accommodations for about 62 students. The rooms in the dormitories are occupied by the upper classmen, hence new students find it necessary to room in private houses. The rooms in the college dormitories are unfurnished; for the most part they are arranged in suites of three, — one study room and two bedrooms. These rooms are heated by steam and lighted by electricity; they are cared for by students occupying them. The dormitory rent for each person varies from $39 to $66 a year. The rent for furnished rooms in private houses ranges from $1 to $3 a week for each occupant. Correspondence in regard to rooms should be addressed to the dean of the college.

Board may be obtained at the college dining hall. At present, the price of board there is about $6 a week.

Expenses.

The necessary college expenses are estimated as follows: —

Tuition: citizens of Massachusetts, free; other citizens of the United States, $60 a year; foreigners, $120 a year.

	Low.	High.
Matriculation fee, first year,	$5 00	$5 00
Room in college dormitories or in private houses,	39 00	110 00
Board, $5 to $6 per week,	180 00	216 00
Laundry, 50 to 85 cents a week,	18 00	30 00
Military uniform, first year,	19 00	19 00
Laboratory fees,	5 00	20 00
Books, stationery and miscellaneous items,	14 00	25 00
	$280 00	$425 00

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[1] This statement applies to those registering as regular or unclassified students.

OTHER EXPENSES. — Prospective students should understand that the above estimates cover expenses which may be called strictly college expenses, and that there are other financial obligations voluntarily placed upon students which they should expect to meet. Chief among these are class assessments and taxes levied for maintenance of various organizations, such as the Social Union, Athletic Association, weekly publications, etc. Such expenses vary from $15 to $30 a year. Additional financial responsibility is also assumed by students joining a fraternity or entering into other social activities of the college. Students rooming in college dormitories are obliged to equip their own rooms with furniture. The college assumes no responsibility in regard to the safe keeping of student property either during the college term or vacations, except under such special arrangement as may be made with the treasurer. Besides the amount necessary for clothes and traveling, the economical student will probably spend between $300 and $425 per year.

INITIAL CHARGES.

At the opening of the college year, before students are registered in their classes, the following charges are payable at the treasurer's office: —

	Freshmen.	Sophomores.	Juniors and Seniors.
Matriculation fee, ...	$5 00	-	-
Board (if at college dining hall) four weeks in advance,	24 00	$24 00	$24 00
Assessment for support of Social Union, . . .	1 50	1 50	1 50
Laboratory fees, ...	5 00	5 00	2 00-10 00
Military uniform,[1]	19 00	-	-
Room rent (if in college dormitory), ...	-	-	12 00-20 00
Student tax for support of athletics,[2] . . .	8 00	8 00	8 00
Student tax for support of nonathletic activities,[2] .	2 50	2 50	2 50

[1] This cost is subject to modification from year to year.

[2] While this is not essentially a college charge, the treasurer of the college acts as collector for the student activity, and all students are expected to make the payment as indicated. The subscription price of the "Collegian" is fixed by the managers; the amount of athletic tax by vote of the student body.

LABORATORY FEES.

The principles observed in establishing laboratory fees are the requirement that students pay for those materials actually used which cannot be supplied by the individual, and that the laboratory fees include a charge sufficient to guard against wanton waste and breakage. Fees may be established for any course without previous announcement. At present, the fees charged are as follows: —

Agronomy: —	Per Term.
Course 27, 3, ...	$1 50
Course 50, 1, ...	2 00
Course 51, 3, ...	2 00
Course 75, 1, ...	1 50
Course 76, 3, ...	1 50

	Per Term.
Animal husbandry: —	
Course 1, 1 and 2,	$1 00
Course 25, 1,	1 50
Course 26, 2,	1 50
Course 50, 2,	1 50
Course 78, 2,	1 00
Dairying: —	
Course 50, 1,	2 50
Course 51, 3,	2 50
Course 75, 2,	2 00
Course 76, 3,	3 00
Course 77, 1,	2 50
Farm administration: —	
Course 75, 2,	1 50
Course 76, 3,	1 50
Poultry husbandry: —	
Course 51, 1,	2 50
Course 53, 3,	3 00
Course 55, 3,	2 50
Course 76, 1,	2 00
Course 77, 1,	2 00
Rural engineering: —	
Course 25, 1,	1 50
Course 26, 2,	1 50
Course 76, 1,	1 50
Course 77, 2,	1 50
Course 78, 3,	1 50
Floriculture: —	
Course 50, 1,	2 50
Course 51, 2,	2 50
Course 52, 3,	2 50
Course 53, 1,	2 50
Course 75, 1,	2 00
Course 76, 3,	2 00
Course 77, 2,	2 50
Course 78, 3,	2 50
Forestry: —	
Course 50, 1,	2 00
Course 51, 2,	3 00
Course 75, 1,	4 00
Landscape gardening: —	
Course 50, 1,	3 00
Course 51, 2,	3 00
Course 52, 3,	4 00
Course 76, 2,	4 00
Course 77, 3,	4 00
Course 79, 3,	2 00
Market gardening: —	
Course 50, 3,	2 00
Course 75, 1,	3 00
Course 76, 2,	3 00
Pomology: —	
Course 75, 1,	3 00
Course 76, 2,	3 00

	Per Term.
Drawing: —	
Course 25, 1,	$3 00
Course 26, 2,	3 00
Botany: —	
Course 3, 3,	3 00
Course 25, 1,	3 00
Course 26, 2,	3 00
Course 50, 1,	3 00
Course 51, 2,	5 00
Course 52, 1,	4 00
Course 53, 2,	4 00
Course 54, 3,	4 00
Course 55, 1,	5 00
Course 56, 2,	5 00
Course 75, 1,	5 00
Course 76, 2,	5 00
Course 77, 3,	5 00
Course 78, 1,	5 00
Course 79, 3,	5 00
Course 80, 3,	5 00
Course 82, 2,	5 00
Course 83, 3,	5 00
Course 84, 2,	5 00
Course 85, 3,	5 00
Entomology: —	
Course 75, 3,	2 00
Course 76, 1,	3 00
Course 77, 2,	3 00
Course 78, 3,	3 00
Chemistry: —	
Course 1, 1,	3 00
Course 2, 2,	3 00
Course 3, 3,	3 00
Course 4, 1,	3 00
Course 5, 2,	3 00
Course 6, 3,	3 00
Course 25, 1,	4 00
Course 26, 2,	4 00
Course 27, 3,	5 00
Course 30, 3,	4 00
Course 51, 1,	5 00
Course 52, 2,	5 00
Course 60, 1,	4 00
Course 61, 2,	5 00
Course 62, 3,	5 00
Course 65, 3,	4 00
Course 76, 1,	5 00
Course 77, 2,	5 00
Course 80, 1,	5 00
Course 90, 2,	5 00
Course 91, 3,	5 00
Course 92, 2,	5 00
Course 93, 3,	5 00
Course 94, 2,	5 00
Course 95, 3,	5 00
Mathematics and engineering: —	
Course 27, 3,	2 00
Course 78, 3,	2 00

	Per Term.
Microbiology: —	
Course 51, 2 and 3,	$5 00
Course 52, 3,	5 00
Course 75, 2,	5 00
Course 76, 3,	5 00
Course 80, 2,	5 00
Course 81, 1,	5 00
Course 82, 1,	5 00
Course 83, 1,	5 00
Physics: —	
Course 27, 3,	3 00
Course 50, 1,	3 00
Course 51, 2,	3 00
Course 52, 3,	3 00
Veterinary science: —	
Course 78, 1,	2 00
Course 79, 1,	2 00
Course 80, 3,	2 00
Course 85, 1,	2 00
Course 86, 2,	2 00
Course 87, 3,	2 00
Zoölogy and geology: —	
Course 25, 1,	3 00
Course Zoölogy 27, 3,	3 00
Course 50, 1,	3 00
Course 51, 2,	4 00
Course 52, 3,	4 00
Course 53, 1,	4 00
Course 54, 2,	3 00
Course 55, 3,	3 00
Course 58,	2 00
Course 75, 1,	3 00
Course 76, 2,	3 00
Course 77, 3,	3 00
Course 78,	2 00
Course 79,	2 00
Rural journalism: —	
Course 53, 1,	2 00
Course 54, 2,	2 00
Course 55, 3,	2 00
Course 77, 1,	2 00
Course 78, 2,	2 00
Course 79, 3,	2 00
Course 80, 1,	2 00
Course 81, 2,	2 00
Course 82, 3,	2 00
Music (each course),	3 00

Rooms.

Students are expected, as far as possible, to occupy rooms in the college dormitories. Students who do not live in the college dormitories must secure rooms approved by the college. The assignment of rooms, and the general supervision of the housing of students, is in charge of the dean. The inspection of student quarters is in charge of the commandant. At the end of each college year all unoccupied rooms will be thrown open for selection, and will be assigned to students according to classes. Freshmen will be assigned rooms according to the date of application.

Women students are expected to occupy rooms in the college dormitory and such houses or apartments as the college may provide. No woman student will be allowed to room in a private house without a special written permission from the dean.

Student Aid.

Self Help. — Many students are obliged to find work of some sort to earn their way through college. A few men have met their entire expenses in this manner, many more have paid a large part of their expenses, and many have earned a small proportion of the cost of their college education; but the college recommends that no new student enter without having at least $150 and preferably $250 with which to pay his way until he can establish himself in some regular work. The college does not encourage students to enter without money in the expectation of earning their way entirely. The ordinary student will find it better either to work and accumulate money before coming to college, or to take more than four years in completing his college course, or, instead, to borrow money sufficient to carry him through. No student should undertake work that interferes with his studies, and students should understand that, owing to the large number of applications for employment, no one man can receive a large amount of work at the college. A number of students find opportunities for earning money without depending upon the college to furnish them with work.

So far as possible needy students will be employed in some department of the college. The divisions of agriculture and horticulture usually afford the most work, although there are several permanent janitorships available for students, and sixty or more students are employed at the dining hall.

Application for student labor should be made directly to Kenyon L. Butterfield, president of the college. Applicants are required to present statements from parent or guardian and from a public official or other responsible person of the town or city in which they reside, explaining the necessity of the applicant's need of assistance. Students whose deportment or class work is not satisfactory are not likely to be continued in student labor. The most desirable and responsible positions are naturally assigned to those needy students who have been in the institution longest and who have demonstrated their need and ability. Students, therefore, may find it rather difficult to obtain all the work they desire during their freshman year; as a matter of fact, however, any student who is capable of doing a variety of things, and who is a competent workman, usually finds little difficulty in obtaining all the work that he can do from the outset.

Special Notice to Needy Students. — In the last few years the demand for paid labor on the part of new students has far exceeded the amount of employment that the college can offer. The college cannot promise work to any student, particularly to freshmen; it accordingly urges prospective students who are dependent entirely upon their own efforts not to undertake the course before they have earned enough money to carry them through, or nearly through, the first year.

Student Accounts.

The following rules are enforced concerning student accounts: —

No student will be allowed to graduate until all bills due the institution from him are paid.

College charges, such as room rent, laboratory fees and tuition, must be paid in advance, at the beginning of each term. This rule is strictly adhered to, and no student will be allowed to complete his registration until such payments are made.

Every student boarding at Draper Hall is required to pay at the beginning of each term at least one month's board in advance; and no student will be allowed to continue to board at Draper Hall if at any time during the term he is more than one week in arrears in his payment for board.

All money due for student labor shall at the discretion of the treasurer of the college be applied on account toward any bills that a student may owe to the institution.

Student Relations.

The customary high standard of college men in honor, manliness, self-respect and consideration for the rights of others constitutes the standards of student deportment.

Any student known to be guilty of dishonest conduct or practice must be reported by the instructor to the president for discipline.

The privileges of the college may be withdrawn from any student at any time, if such action is deemed advisable.

It should be understood that the college, acting through its president or any administrative officer designated by him, distinctly reserves the right not only to suspend or dismiss students, but also to name conditions under which students may remain in the institution. For example, if a student is not doing creditable work he may not only be disciplined but he may also be required to meet certain prescribed conditions in respect to his studies, even though under the foregoing rules his status as a student be not affected. The same provision applies equally to the matter of absences ("cuts"). According to the rules a student is allowed a certain percentage of absences from class and other exercises. This permission, which implies a privilege and not a right, may be withdrawn at any time for any cause.

Similarly, also, it applies to participation in student activities. Though this will ordinarily be governed by the rules as already laid down, yet, if in the judgment of the college authorities a student is neglecting his work on account of these activities, the privilege of participating in them may be withdrawn for such time as is considered necessary. Moreover, it may be withdrawn as a punishment for misconduct. Prospective students or their parents may, upon application, obtain a copy of the faculty rules governing student relations to the college.

Infirmary.

The college maintains an infirmary for the care of sick or injured students. The buildings now available for this purpose are quite inadequate for the needs of the institution, and it is hoped that in the near future other buildings of this kind may be erected and the general equipment somewhat amplified. At present two small buildings, built especially for hospital purposes, are used for the infirmary.

The following statement outlines the plan followed in the management of the infirmary with respect to students: —

MANAGEMENT OF THE INFIRMARY.

Supervision.

1. The infirmary is under the *general supervision* of Prof. Charles E. Marshall who is designated as Supervisor of the Infirmary. Miss Florence Levensaler the resident nurse, is in *immediate* charge of the infirmary.

Use of Infirmary.

2. Students are urged to go to the infirmary at any time that they are in need of the services rendered by the resident nurse or by a town physician. Inasmuch as the physical director gives special attention to all student diseases, it is to be expected that the majority of the students will go to the infirmary at his suggestion. This understanding, however, should in no way deter students from going to the infirmary voluntarily at any time.

General Health.

3. Students are urged to consult the physical director or the resident nurse immediately when signs of physical disorder appear. Severe attacks of cold or other forms of illness can usually be avoided if treatment is administered in the incipient stage. The purpose of the infirmary is to help maintain the general good health of the students, as well as to furnish a suitable place for professional attention in cases of severe illness or accident.

General Fee.

4. The infirmary fee will be at the rate of $1.50 a day, and will be charged when one or more meals are obtained at the infirmary, or when the student remains at the infirmary for one or more nights. A nominal charge will be made to out patients for miscellaneous treatment of a minor character.

Additional Expenses.

5. In addition to the fee charged, as specified in paragraph 4, the following additional expenses will be charged to the patient: —

(*a*) *Nurses.* — In case a special nurse is required for the proper care of an individual, the services and board of this nurse will be paid by the patient. Such a nurse will be under the general supervision of the resident nurse.

(*b*) *Professional Service.* — If a student requires medical attention by a physician, he will be required to select his physician and become responsible for fees charged by the physician.

(*c*) *Supplies.* — Special medical supplies prescribed by a physician or nurse will be charged to the patient.

(*d*) *Laundry.* — Expense for personal laundry incurred by students while in the infirmary will be charged to the individual student.

B. COLLEGE ACTIVITIES.

General Exercises.

Chapel exercises are held two mornings each week. On Wednesday an afternoon assembly is held, to which some prominent layman or professional man is invited to speak. The object of these assemblies is to bring to the students discussions of topics of present-day interest. A special chapel service on Sunday is usually held during the winter months. Students are required to attend these general exercises, although the president is authorized to excuse from chapel any student who may object to attendance thereon because of his religious scruples, provided his request for excuse therefrom is endorsed by his parent or guardian.

Student Activities.

A large number of student organizations furnish opportunity to students for work and leadership.

The Massachusetts Agricultural College Social Union was established about six years ago. All students become members of the union by paying a small fee. The union is designed to become the center of student interests. In North College it has a trophy room and a large lounging room for music, reading and study; in the basement of this building there is also a game room for pool and billiards. In the fall and winter months the union gives a series of entertainments, free to students and faculty.

The College Senate is composed of representatives of the junior and senior classes. This body serves as a general director of undergraduate conduct, and represents before the faculty the interests of the student body.

The Young Men's Christian Association is active both socially and religiously. A Catholic club has also been organized.

The musical organizations include an orchestra, a mandolin club and a glee club. These furnish music for college meetings, and occasionally give concerts at the college and at other places. A military band is maintained as part of the cadet corps.

A dramatic club has been organized, and each year presents a play.

The Public Speaking Council represents the students' interest in debate and oratory.

The Athletic Association represents in the college the interests of football, baseball, track, hockey and basket ball.

A rifle club has been organized for a few years. Teams representing this club have repeatedly won the intercollegiate championship of the country, both in indoor and outdoor contests.

The college publications are the "Massachusetts Collegian" published weekly by the student body, and the "Index," published annually by the members of the junior class.

The Stockbridge Club is an organization of students especially interested in practical agriculture and horticulture. Regular meetings are addressed by outside speakers, and members present papers and engage in discussions.

Clubs also exist in the Departments of French, Entomology, Floriculture, Landscape Gardening, Zoölogy and Agriculture Economics.

There has recently been organized a Collegiate Country Life Club, the membership of which is composed of faculty and students who are particularly interested in the study of country life problems.

A nonathletics student activities board, composed of alumni, faculty and students, has charge of the finances, schedules, etc., of the musical clubs, dramatic club and student publications.

C. ACADEMIC AND DEPARTMENTAL.

Degrees.

Those who complete a four-year course receive the degree of bachelor of science. The fee for graduation from the college is $5.

Graduate students who complete the assigned courses will receive the degree of master of science upon the payment of a fee of $10. Credit may sometimes be allowed towards this degree for teaching or other advanced work done in some department of the college.

Graduate students who complete the required three-year course of study, and present a satisfactory thesis, will be granted the degree of doctor of philosophy.

Those to whom degrees are awarded must present themselves in person at commencement to receive them. No honorary degrees are conferred.

The honorary fraternity of Phi Kappa Phi has a chapter at the agricultural college. Students are elected to membership to this fraternity on the basis of scholarship. Elections are made from the highest fifth of the senior class who have attained an average grade of at least 85 per cent. during their college course.

Prizes.

Prizes are given annually in several departments for excellence in study or for other special achievement. Prizes offered in 1914 were: —

Agriculture. — The Grinnell prizes, given by Hon. William Claflin of Boston in honor of George B. Grinnell, Esq., of New York, for excellence in theoretical and practical agriculture. Three prizes, $25, $15, $10. The contest is open to those senior students whose record on the registrar's books shows an average standing of 80 or above for the technical work taken in the Divisions of Agriculture and Horticulture during the junior and senior years. Applicants should register with the head of the Division of Agriculture before noon, June 2, 1918.

Animal Husbandry. — The F. Lothrup Ames prize, given by F. Lothrup Ames, Langwater Farms, North Easton, Mass., consisting of $150 a year, offered for a period of five years, beginning 1912, to be given to the three students standing highest in the work of advanced live stock judging, and to be used in defraying their expenses incurred by participation in the students' judging contest at the National Dairy Show, Chicago.

Botany. — The Hills prizes, given by Henry F. Hills of Amherst, amount to $35 annually. Competition is open to members of the senior, junior and sophomore classes as follows: for the best herbarium, $20; for the second best herbarium, $15. No collection deemed unworthy of a prize will be considered.

General Improvement. — The Western Alumni Association prize ($25) is given to that member of the sophomore class who, during his first two years in college, has shown the greatest improvement in scholarship, character and example.

Public Speaking. — The Burnham prizes are awarded as follows: to the students delivering the best and second best declamations in the Burnham contest, $15 and $10, respectively. The preliminary contests in declamation are open, under certain restrictions, to freshmen and sophomores.

The Flint prizes are awarded as follows: to the students delivering the best and second best orations in the Flint contest, a gold medal and $20 and $15, respectively. The preliminary contests in oratory are open, under certain restrictions, to all regular students.

The prizes in debate are awarded as follows: to each of the three students ranking highest in the annual debating contest, a gold medal and $15. The preliminary contests in debate are open, under certain restrictions, to all regular students.

Equipment.

Agricultural Education. — The courses in this department are planned primarily for those who are preparing to teach. The work is carried on by means of lectures, library and demonstrations. The department has an office, lecture room and a laboratory in the Veterinary Science building. The laboratory is equipped with a balance, dishes, jars, reagent bottles, test tubes, petri dishes, lenses, a Babcock test, a Wisconsin sediment test, Bunsen burner, hot and cold water, electricity, gas and other appliances for giving demonstration and practice lessons in Secondary Agriculture. There is also equipment for conducting children's gardens on the campus. Instruction in school gardens constitutes a part of the practice work of those training for the occupation of teaching. Some practice work in teaching is done in the grammar grades of the Amherst schools, and in the agricultural departments of Hopkins' Academy, and Smith's Agricultural School at Northampton. This department is also intimately related to the matter of recommending candidates for teachers' certificates. At least four courses in the department are required of students preparing for such certificate. The office is supplied with school and college reports, also a large number of pamphlets and bulletins relating to the subject of agriculture in the schools, courses of study, etc. See note relative to teachers' certificates, under major in Agricultural Education.

Agronomy. — The work in agronomy is carried on by means of lecture, laboratory and field work. The soil laboratories are located in the basement of Stockbridge Hall, and include an elementary laboratory with locker equipment for 200 men, and desk space for four divisions of 50 men each, and an advanced soil laboratory for the work of upper classes, with locker space for 80 men. This laboratory is also equipped with balance room, centrifuge room, steam ovens and moisture cabinets. There is also a workroom attached, equipped with power for grinding soils, fodders and the like.

The crop laboratories are located on the second floor of Stockbridge Hall, the room for seed study being at the south end and allowing for sections of 50 men each. The laboratory for cereal and forage crop work is at the north end of the building, and has locker equipment for 64 men. This laboratory is equipped with large steam ovens, constant temperature electric ovens, Brown-Duval moisture apparatus and ovens for seed germination. Attached is a balance room and also a storeroom; while on the fourth floor of Stockbridge Hall is a room equipped for the storage of seed corn, grains and grasses.

Animal Husbandry. — An accurate and definite knowledge of the market types and grades, and of the various breeds of live stock, is fundamental to the work in this department. The department is equipped with an excellent laboratory, Grinnell Arena, which has a seating capacity of 180, and which is fully adapted to the requirements. There are upwards of 125 head of dairy cattle of various ages available for class-room work; among these are included superior representatives of the Jersey, Guernsey, Ayrshire and Holstein breeds. There are flocks of pure-bred Shropshire and Southdown sheep of the best breeding and individuality. Considerable numbers of pure-bred Berkshire and Yorkshire pigs are maintained. The college possesses pure-bred Percherons and French coach horses besides many work teams of different types, which are available for class-room purposes. A set of plaster of Paris models of individuals of foreign and domestic breeds of horses, cattle, sheep and swine, and a collection of the different foodstuffs available for the use of the New England farmer, are included in the equipment for this work. An excellent set of upward of 250 lantern slides, portraying the leading prize-winning, producing and breeding animals of the leading breeds, — horses, cattle, sheep and swine, — belongs to this department, and is regularly used in instructional work. This equipment is being added to from time to time as funds are available.

Botany. — The Department of Botany occupies Clark Hall, a brick building 55 by 95 feet, two stories high, with basement and attic. It has two lecture rooms, one seating 154 and the other seating 72 people; one seminar and herbarium room; a large laboratory for freshman and sophomore work, and one for junior and senior work; a laboratory for plant physiology, which is well supplied with apparatus for the study of simple phenomena in plant physiology, such as respiration, metabolism, transpiration, heliotropism, etc.; and three rooms specially fitted for graduate students. The experiment-station laboratories devoted to botanical research are also in this building. A small museum contains material especially useful in the teaching and illustration of plant phenomena; and on the third floor is a collection of Massachusetts timber trees, specimens showing peculiar formations of plant growth, and various specimens illustrative of scientific methods of treating trees. A conservatory 28 by 70 feet is connected with the laboratory. This is designed for experimental work and for housing material often needed for instruction.

The laboratories and lecture rooms are of modern construction, finely lighted and supplied with modern compound microscopes, dissecting microscopes, microtomes and other apparatus, and a large series of charts. In addition to a physiological laboratory the basement contains a seed and soil room, and a convenient workshop provided with benches for wood and metal work, an electric motor, a power lathe and other tools and appliances. The herbarium contains about 18,000 sheets of flowering plants and ferns, 1,200 sheets of mosses, 1,200 sheets of lichens and liverworts, and over 20,000 specimens of fungi.

Chemistry. — The college Department of Chemistry occupies the entire building previously known as the "old chapel." The basement is used for the storage of apparatus and chemicals. The first floor contains large laboratories devoted to organic, physiological and physical chemistry, and qualitative analysis. The second floor is occupied by the general lecture room, by offices for the several members of the staff and by laboratories for analytical chemistry. The third floor has been fitted for work in general chemistry, and has desk room and hoods sufficient to accommodate 90 students at one time. Each place is supplied with reagents and apparatus for independent work. This floor is also occupied by a lecture room that will seat 56 students.

The entire laboratory is well equipped with the necessary apparatus and chemicals for all students who desire to perfect themselves as expert chemists, or who wish to study chemistry as a supplement to some other line of practical or scientific work. The equipment includes a valuable and growing collection of specimens and samples of minerals, soils, raw and manufactured fertilizers, foods, milk products, fibers, various other vegetable and animal products and artificial preparations of mineral and organic compounds; and also a series of preparations for illustrating the various stages of different manufactures from raw material to finished product.

Dairying. — The dairy work is given in Flint Laboratory, a new building designed for the dairy department. It contains large, well-lighted, sanitary and well-equipped laboratories. The equipment is new and of the best types of market milk and farm dairy machines.

Dining Hall. — Draper Hall, a brick colonial building equipped with the modern conveniences of a dining hall, was opened in 1903. The dining service is under the supervision of the college. The building contains a limited number of rooms for young women students.

Drawing. — The class in drawing occupies a room on the second floor of Wilder Hall. It is equipped with tables and adjustable drawing stands. The necessary materials and implements are provided. The equipment includes drawing models, and plaster casts of leaves, flowers, fruits, human and architectural details and garden ornaments, two universal drafting machines, an eidograph, centrolineads, a set of ship splines and French curves, complete water-color outfits, automatic crosshatchers and protractors.

Entomology. — *General Entomological Laboratories.* — The equipment for work in entomology is perhaps unexcelled in this country. In the new fireproof entomological and zoölogical building, first used in the fall of 1910, are fine lecture rooms, laboratories and museums for use in the different courses. The senior laboratory will accommodate 70 students at one time; a desk, equipped with compound microscope and accessories, together with glassware, reagents, etc., and supplied with electric light and gas, is provided for each student. Dissecting microscopes, microtomes and other apparatus are available for use. The graduate laboratory is similarly equipped, and it will accommodate 20 students. The large and rapidly growing collections of insects are in a room adjoining both laboratories. In the library of the building is an excellent collection of the more important books and journals treating of entomology, and many more are accessible in the college library and in the private libraries of the professors, in all making available more than 25,000 volumes, many of which cannot be found elsewhere in the United States. A card catalogue giving references to the published articles on different insects contains more than 60,000 cards, and is the largest index of its kind in the United States, and probably in the world. In the basement is a pump room where may be studied the construction of the different types of spray pump and methods of repairing them; hose, couplings, nozzles and the other parts of spraying outfits are provided, not only for examination but for use. In another room chemical desks and apparatus provide opportunities for the determination of the impurities and adulterations of insecticides. As the insectary of the Massachusetts Agricultural Experiment Station is in the same building the facilities it offers are also available. A greenhouse, where plants infested with injurious insects are under observation and experimental treatment, is also open to students. Photographic rooms with cameras and other photographic apparatus are provided, and the large greenhouses, gardens, orchards and grounds of the college offer further opportunities for the study of injurious insects under natural conditions.

ENTOMOLOGY. — *Beekeeping.* — For this work the main office, museum and lecture rooms are in the entomological building. There is also an apiary covering approximately two acres which will consist of about fifty colonies of bees in various types of hives and maintained for the several practical and experimental purposes. The apiary also includes a collection of nectar-yielding plants representative of the native flora as well as of the more important nectar sources from other localities. Especial opportunity is therefore given for a study of this fundamental problem of forage. Upon the apiary site is an eight-room building (the first in the world erected exclusively for teaching beekeeping) modeled to meet both the requirements of teaching and of a practical apiary. This building contains a boiler room, capacious wintering cellar, wax extraction room, general carpenter and work shop, laboratory, office, honey extraction room and stock room. The beekeeping equipment also includes an unexcelled collection of apicultural implements, natural history specimens and other curiosities. Practically every device used in American apiculture is available, it being the aim of the department to procure new inventions and implements as fast as they appear for the purpose of study and comparison. Available to the students is a private library of apicultural literature consisting of upwards of 900 volumes and papers, possibly the most complete collection in the country. This entire equipment is acknowledged unique in model and in completeness for the United States and for the world.

FARM ADMINISTRATION. — The college farm of 250 acres is under the general supervision of the Department of Farm Administration, and furnishes demonstration material. It includes improved land, pasture land and a farm wood lot. The improved land illustrates the value of good culture and the best known methods for the maintenance of fertility. The farm is equipped with suitable buildings and good machinery for the work carried on, of which the production of certified milk is an important branch. Several good farms in the vicinity, illustrating types of both special and general agriculture, may be inspected and studied. The offices of the department are in Stockbridge Hall.

FLORICULTURE. — The Department of Floriculture aims to give the student a thorough knowledge of all phases in greenhouse design and construction and greenhouse heating, and in the culture of florists' crops. It is intended to train men for commercial floriculture and for the management of conservatories on private estates and parks and in cemeteries. The course is outlined to combine theoretical, technical and practical work in the most comprehensive manner possible. Probably no agricultural college has a Department of Floriculture better equipped than this. There has been erected a durable, practical, commercial range, composed of palm, fern, orchid, violet, carnation, rose and students' houses. French Hall, with its large laboratories, class rooms and offices, furnishes excellent facilities for the purposes of instruction. Besides the new glass houses, there are older houses suitable for growing bedding plants and chrysanthemums, and frames for the growing of annual and herbaceous perennial plants, violets and pansies. Many excellent specimens of trees and shrubs are growing on the college grounds, furnishing valuable material for the study of plant materials.

Forestry. — The Department of Forestry has an unusually complete equipment of the various instruments used in forest mensuration, forest mapping and engineering, timber estimating, log scaling, board measuring, etc.; a large assortment of boards illustrative of the various commercial woods found in the lumber markets. The State Forest Nursery, comprising 6 acres of land and containing, approximately, 5,000,000 trees, transplants and seedlings, is located on the college farm. Extensive forests containing every variety of tree common to New England are within walking distances of the college. The college campus affords an arboretum containing an exceptionally large number of trees not native to New England. The library contains complete sets of government bulletins, circulars, State reports and all the best books on forestry subjects. The recent designation of Mt. Toby as a forest reservation provides more than 700 acres of forest, representing nearly every forest growth within the State.

Geology. — A large, well-lighted laboratory for geology, 27 by 50 feet, is in the basement of the new building for entomology, zoölogy and geology. This is equipped with cabinets, models, charts and a teaching collection of rocks. It has a seating capacity of 50 persons. Adjoining this is a smaller laboratory, 21 by 27 feet, for mineralogy, supplied with gas and cabinets for models, crystals and minerals. There is also a small laboratory for grinding thin sections, and a private laboratory, 6 by 19 feet, for analysis work. The geological museum is 27 by 48 feet. It has six large cases for exhibition purposes. The equipment for geology is being enlarged. At present, in addition to the general items mentioned above, it consists of a petrographic microscope, an illustrative series of thin sections, a small collection of invertebrate fossils, some casts of vertebrate fossils, a collection of the building stones of Massachusetts, and a duplicate set of the Edward Hitchcock survey collection of the rocks and minerals of Massachusetts.

Heating, Lighting and Power. — The college supplies its own light, heat and power, including electricity for the night lighting of the campus and its approaches. The machinery of the barn, the dairy and other buildings is operated by electricity generated at the power-house. The college has also a machine shop and well-equipped carpenter shop.

Landscape Gardening. — The work in landscape gardening is developed in a strong technical four-year course; the first two years are occupied with required studies, including botany, horticulture, surveying and mathematics, and the last two years are devoted to more specialized studies in landscape gardening, arboriculture, floriculture, entomology, botany and mathematics. The environment is unusually favorable. The strictly technical work in landscape gardening is taught in light and comfortable drafting rooms, fully furnished with instruments and accessories for thorough work. There is a well-selected library, and the equipment of surveying and drafting instruments is unusually complete and practical.

Library. — The library — stack room, reading room and office — occupies the entire lower floor of the Chapel-library building. It contains about 56,090 volumes and a large number of bulletins, farm papers and other material, which is being put into good working order as fast as possible. Works on agriculture, horticulture, botany, entomology and the various sciences predominate, but literature, history and sociology are well represented and receive due attention. The reading room provides a good variety of popular and technical periodical literature, encyclopedias and general reference books.

The library is being reclassified and recatalogued in order to make the splendid material accessible and of the greatest working value. Every effort is being made toward developing the college library into a vital intellectual center, of equal value to every student, teacher and teaching department on the college campus. Consequently only the most cordial relations are cherished, and the fewest and most imperative rules concerning the circulation of books and deportment are enforced. An agricultural reference library is maintained in Stockbridge Hall, and department libraries are also maintained in some of the other buildings on the campus.

Occasional lectures are given to regular and short-course students in order to make the best use of the library equipment. Emphasis is laid upon the card catalogue, periodical indexes, bibliographies and guides, and the large collections of United States Department of Agriculture and experiment station literature.

Library hours are from 7.30 A.M. to 9.30 P.M. every week day, and from 9 A.M. to 1.30 P.M. on Sundays in term time. Shorter hours prevail during vacation.

MARKET GARDENING. — The purpose of the courses in market gardening is to acquaint the student with the theories and practice of market gardening so that he will be able to carry on the business intelligently. The equipment available for practical work consists of 10 acres of good gardening land; a large collection of horse and hand garden tools; hot-beds and cold-frames; and lettuce, cucumber and tomato houses. The students therefore have opportunity both to study and to practice the important branches of the business. Classes are taught in French Hall, a new building fitted with class rooms and laboratory particularly equipped for market gardening. A good library of works on vegetable gardening is available.

MATHEMATICS AND CIVIL ENGINEERING. — *Surveying.* — The department has a considerable number of the usual surveying instruments, with the use of which the students are required to become familiar by doing field work. Among the larger instruments are 2 plain compasses, a railroad compass with telescope, a surveyor's transit, 3 engineer's transits with vertical arc and level, a Brandis solar transit, a solar compass, an omnimeter with verniers reading to 10 seconds, adapted to geodetic work, a Queen plane table, 3 wye levels, 2 dumpy levels, a builder's level, a sextant, a hand level, and a large assortment of leveling rods, flag poles, chains, tapes, etc. For drafting, a vernier protractor, a pantograph, a parallel rule, etc., are available. The department also has a Fairbanks cement testing outfit.

MICROBIOLOGY. — The department now occupies a newly erected building, and has at command laboratories, research rooms, offices and class-rooms, of thoroughly modern completeness.

MILITARY SCIENCE. — This department makes use of the campus for battalion drill, and has a special building in which there is a drill room 60 by 135 feet, an armory, an office for the commandant, a field-gun and gallery practice room and a large bathroom. The national government supplies Krag-Jorgensen rifles, with complete equipments and ammunition. The State supplies instruments for the college band. Students are held responsible for all articles of public property in their possession. The college owns an excellent target range for rifle practice, lying a short distance out of the village.

Physical Education. — The gymnasium and armory has a floor space of 5,000 square feet, and is 30 feet high, well lighted and ventilated. The main floor is used for basket ball, indoor baseball and hand ball. The gallery has been fitted up as a special exercise and gymnastic room, and is equipped with modern developing apparatus, including parallel bars, horses, bucks, chest weights, dumb-bells, Indian clubs and striking bags. An outdoor board track enables students to secure track practice through the winter, and two ice hockey rinks give ample opportunity for hockey practice. Credit is given to all students taking part in outdoor activities. "Treks" are held twice a week, and whenever possible snowshoe and skiing hikes are also held. Steel lockers and bathrooms have been installed in North and South colleges, and the gymnasium has been fitted with a shower-room. The gymnasium classes are held the last two hours in the morning and the last two hours in the afternoon, but students may use the gymnasium at other times for exercise purposes by arrangement with the department. The regulation costume for class exercise consists of a white track suit and white rubber-sole shoes.

Physics. — Among the apparatus in use for instruction in general physics are a set of United States standard weights and measures, precision balances, a spherometer, vernier calipers, a projection lantern, etc.; in mechanics, a seconds clock, systems of pulleys and levers, and apparatus to illustrate the laws of falling bodies and motion on an inclined plane, and the phenomena connected with the mechanics of liquids and gases. The department is equipped with the usual apparatus for lecture illustration in heat, light and sound; in electricity, the equipment consists of apparatus for both lecture illustration and laboratory work, including a full set of Weston ammeters and volt meters, a Carhart-Clark standard cell, a Mascart quadrant electrometer, a Siemens electro-dynamometer, and reflecting galvanometers and Wheatstone bridges for ordinary determinations of currents and resistances.

Pomology. — The Department of Pomology has 45 acres of orchard, including apple, pear, peach, plum, cherry and quince trees. There are also two commercial vineyards, and a smaller one in which are shown the principal types of trellis and the leading methods of training grapes. Several acres are used in growing the various kinds of small fruits, such as strawberries, raspberries, blackberries, currants and gooseberries. There are also nurseries, where all of these various types of fruits are grown, in which students may see them in all stages of development.

The department has a good equipment of orchard and nursery tools of all the principal types, the use of which enables students to learn the value of each type. For other orchard operations, such as spraying and pruning, the most approved makes of pumps, nozzles, pruning saws, knives, etc., are provided. For laboratory work in systematic pomology there is a collection of more than 100 wax models of apples, plums, pears and peaches, in natural colors. The laboratory is also furnished with a large number of reference books on pomology; and fruit in a fresh condition is available in great variety, not only from the college orchards but from other parts of Massachusetts and from many other States. In 1916–17, for instance, apples for class use were received from Idaho, Missouri, Utah, Washington, Maine, Connecticut, Pennsylvania, Montana, Minnesota, Nebraska, Kentucky, Iowa, Wisconsin, Michigan, New York, Kansas, Colorado, Oregon, New Jersey and Vermont, besides collections of grapes from California and citrus fruit from Florida and Texas. From the college fruit plantations the following fruits were available: grapes, fifty varieties, representing three native American species and several hybrids; twenty varieties of peaches, twenty varieties of pears, twenty-five varieties of plums, one hundred varieties of apples.

POULTRY HUSBANDRY. — The poultry plant consists of about 9 acres of land sloping gently to the west. The soil is a fine, rich, sandy loam, well drained. At present the buildings consist of an incubator cellar, 22 by 34 feet, with a capacity of 4,000 eggs, over which is a demonstration building; a pipe brood house (open-pipe system), 14 by 72 feet, which will accommodate 1,200 chickens; a long laying house, 14 by 180 feet, which accommodates 500 layers and furnishes facilities for student work in pen management; a laboratory, 14 by 80 feet, for killing, picking, dressing, crate fattening, cramming, etc.; a storage building, 28 by 42 feet, for experimental incubation, poultry carpentry, poultry mechanics and storage; an experimental breeding house, 18 by 60 feet; a combination laying, testing and breeding house, 18 by 72, for experimental purposes, and a model laying house, 18 by 30, for 100 hens; the 6 old experiment-station buildings, each 12 by 18 feet, to be used as breeding houses; 14 colony houses; 8 growing crops; a manure shed, 14 by 18 feet; and an oil house, 10 by 12 feet. Instruction in this department is given in the form of lectures, demonstrations and practical work. The practical work consists of poultry carpentry, caponizing, killing, picking, dressing, packing and selling poultry; pen management and fattening; running incubators and brooders, etc. At present the stock consists of 20 leading varieties of poultry. The aim of the department is to keep good specimens of all the most popular varieties of chickens, ducks and geese, so that a thorough course in poultry judging may be given, and that visitors may find the inspection of our stock an education in itself.

PUBLIC SPEAKING. — In connection with the work in public speaking, three regular contests are held during the year. The Burnham contest in declamation is open to freshmen and sophomores; the Flint contest in oratory and the annual debating contest are open (under restrictions) to all regular students. These contests offer a very practical and necessary experience to all students interested in improving themselves in the art of public speaking. Prizes are given for excellence in the contests. Intercollegiate contests are arranged by the Public Speaking Council. One credit is given, except to freshmen, for a year of work in the College Debating Club.

RURAL ENGINEERING. — This department has an office and the use of a lecture room in Stockbridge Hall. The work on farm structures is given in the large drawing room in the same building. This room is fitted with thirty drawing tables. Models and blue prints are available for the study of farm buildings. A set of post molds and a machine for making cement tile afford opportunity for practical work with cement.

The rural engineering shop building is a one-story structure 68 by 126 feet. The carpenter shop in this building is fitted with benches fully equipped with tools for each student. A saw table is available for getting out material. The general repair shop is equipped with forges, benches, a drill press and grinders. The laboratory for farm machinery and farm motors is equipped with a complete line of field machines, gasoline engines and pumps. A small dynamo and switchboard are used in the study of farm-lighting systems.

The work on the small field machines is given in the basement of Stockbridge Hall, and the work on steam engines and steam heating is given in Flint Laboratory.

Rural Journalism. — The news-room, or laboratory, for the courses in rural journalism, is equipped with typewriting machines, copy tables, representative newspapers, reviews, agricultural papers, and trade journals concerning journalism and writing, selected books on journalism, reference books, and a considerable "morgue" of indexed pamphlets, monographs and clippings on farming, rural life and rural industry, contemporary events, etc. (loan collection). The news-room and offices are in the recently completed Stockbridge Hall, near the division library of the Division of Agriculture.

Veterinary Science. — The department of Veterinary Science occupies a modern laboratory and hospital stable, built in accordance with the latest principles of sanitation. Every precaution has been taken in the arrangement of details to prevent the spread of disease, and to provide for effective heating, lighting, ventilation and disinfection.

The main building contains a large working laboratory for student use, and several small private laboratories for special work. There is a lecture hall, a museum, a demonstration room, a photographing room and a workshop. The hospital stable contains a pharmacy, an operating hall, a post-mortem and dissecting room, a poultry section, a section for cats and dogs, and 6 sections, separated from each other, for horses, cattle, sheep and swine. The laboratory equipment consists of a dissectible Auzoux model of the horse and Auzoux models of the foot and the leg, showing the anatomy and the diseases of every part. The laboratories also have modern, high-power microscopes, microtomes, incubators and sterilizers, for work in every department of veterinary science including pathology, serology and parasitology. There are skeletons of the horse, the cow, the sheep, the dog and the pig, and a growing collection of anatomical and pathological specimens. The lecture room is provided with numerous maps, charts and diagrams.

Zoölogy. — The college offers increased facilities for the study of zoölogy. In the new building for entomology, zoölogy and geology are spacious laboratories for both undergraduate and graduate work. On the first floor is a large sophomore laboratory, 27 by 100 feet, with a present seating capacity of 100 persons. Adjoining this is a smaller room, 20 by 27 feet, for junior and senior courses. All laboratories are equipped with gas. The equipment consists of 80 compound microscopes and accessories, 70 dissecting microscopes, microtomes and accessories, paraffine baths, incubator, dissecting instruments, glassware and other necessary apparatus.

The large amphitheater lecture hall is used jointly by the Departments of Entomology and Zoölogy-Geology. It is equipped with charts and models. The zoölogical museum is drawn upon at all times for illustrative material. The zoölogical museum is 27 by 48 feet. The main room is on the first floor of the building. Above this, on a level with the second floor, is a large gallery. On the main floor are 8 large wall cases and 5 large floor cases for exhibition purposes. The gallery has 1 large wall case and 3 floor cases with space for 9 additional cases. The zoölogical collection consists of nearly 12,000 specimens. All the chief phyla are represented. Adjoining the museum is a preparator's room for the curator. The museum is open to the public from 1 to 5 p.m. on Saturdays, and on other week days from 3 to 6 p.m. The curator is Professor Gordon.

List of Awards and Prizes, 1917.

Due to the early closing of college in 1917, no contests were held for the Grinnell prizes, the Hills botanical prizes or the public speaking prizes.

General Improvement. — The Western Alumni Association prize, given to that member of the sophomore class who, during the first two years in college, has shown the greatest improvement in scholarship, character and example, $25. Awarded to William Mather, 1919.

Military Honors. — The following-named cadet officers have been granted the military diploma, and have been reported to the Adjutant-General of the United States army and to the Adjutant-General of the Commonwealth of Massachusetts as being efficient in military science and tactics and graduating therein with highest honors: —

Cadet Col. Oliver Simeon Flint.
Cadet Maj. Walter Adams Mack.
Cadet Maj. Almon Whitney Spaulding.
Cadet Maj. Lewis Taylor Buckman.
Cadet Capt. Charles Henry Hagelstein.
Cadet Capt. Harold Barnard Pierce.
Cadet Capt. William Saville, Jr.
Cadet Capt. Albert Briggs Loring.
Cadet Capt. Monsell Henry Davis.
Cadet Capt. William Raymond Irving.
Cadet Capt. Philip Rodney Babcock.

Secretaries of Alumni Associations.

Associate Alumni of the Massachusetts Agricultural College.
Secretary: Dr. Charles A. Peters, 1897, Amherst, Mass.
Alumni Secretaries' Association of the Massachusetts Agricultural College.
Secretary: Ralph J. Watts, 1907, Amherst, Mass.
Alumni Club of Massachusetts.
Secretary: Edward C. Edwards, 1914, 50 State Street, Boston, Mass.
Connecticut Valley Association of the Massachusetts Agricultural College.
Secretary: Robert S. Fay, 1913, Monson, Mass.
Massachusetts Agricultural College Club of New York.
Secretary: Walter L. Morse, 1895, Grand Central Terminal, New York.
Massachusetts Agricultural College Club of Washington, D. C.
Secretary: G. A. Billings, U. S. D. A., Office of Farm Management, Washington, D. C.
Western Alumni Association of the Massachusetts Agricultural College.
Secretary: Theodore J. Morean, 1912, 815 Steinway Hall, Chicago, Ill.
Massachusetts Agricultural College Pacific Coast Alumni Association.
Secretary: Thomas F. Hunt, 1905, Berkeley, Cal.
Massachusetts Agricultural College Club of Hawaii.
President: Allen M. Nowell, 1897, Honolulu, T. H.
Massachusetts Agricultural College Club of Worcester County.
Secretary: Charles H. White, 1909, 11 Foster Street, Worcester, Mass.
Massachusetts Agricultural College Club of Marlborough.
Secretary: William L. Howe, 1908, Marlborough, Mass.
Massachusetts Agricultural College Club of Connecticut.
Secretary: Herbert J. Baker, 1911, Storrs, Conn.

Class Secretaries.

Class of —	SECRETARY.	Secretary's Address.
1871	E. E. Thompson,	5 Jacques Avenue, Worcester, Mass.
1872	F. E. Kimball,	17 Harvard Street, Worcester, Mass.
1873	C. Wellington,	Amherst, Mass.
1874	D. G. Hitchcock,	Warren, Mass.
1875	P. M. Harwood,	Room 136, State House, Boston, Mass.
1876	C. Fred Deuel,	Amherst, Mass.
1877	Atherton Clark,	231 Waverley Avenue, Newton, Mass.
1878	C. O. Lovell,	201 Darke Block, Regina, Saskatchewan, Can.
1879	R. W. Swan,	41 Pleasant Street, Worcester, Mass.
1880	Alvan L. Fowler,	413 Federal Building, Philadelphia, Pa.
1881	J. L. Hills,	59 North Prospect Street, Burlington, Vt.
1882	G. D. Howe,	38 Whittier Avenue, Springfield, Mass.
1883	J. B. Lindsey,	Amherst, Mass.
1884	E. A. Jones,	New Canaan, Conn.
1885	E. W. Allen,	1923 Biltmore Street, Washington, D. C.
1886	Winfield Ayres,	616 Madison Avenue, New York City.
1887	F. H. Fowler,	Shirley, Mass.
1888	H. C. Bliss,	14 Mechanic Street, Attleboro, Mass.
1889	F. W. Davis,	85 Colberg Avenue, Roslindale, Mass.
1890	David Barry,	398 Walnut Street, Newtonville, Mass.
1891	H. T. Shores,	177 Elm Street, Northampton, Mass.
1892	H. M. Thomson,	Amherst, Mass.
1893	F. A. Smith,	Hathorne, Mass.
1894	S. F. Howard,	Northfield, Vt.
1895	E. A. White,	Ithaca, N. Y.
1896	A. S. Kinney,	South Hadley, Mass.
1897	C. A. Peters,	Amherst, Mass.
1898	W. S. Fisher,	Peace Street Grammar School, Providence, R.I.
1899	Herbert W. Dana,	9 Oliver Street, Salem, Mass.
1900	E. K. Atkins,	15 Hubbard Avenue, Northampton, Mass.
1901	J. H. Chickering,	Dover, Mass.
1902	H. L. Knight,	1420 Buchanan Street, Washington, D. C.
1903	G. D. Jones,	North Amherst, Mass.
1904	P. F. Staples,	East Holliston, Mass.
1905	A. D. Taylor,	1900 Euclid Avenue, Cleveland, Ohio.
1906	Richard Wellington,	2314 Scudder Street, St. Paul, Minn.
1907	Clinton King,	31 Elm Street, Springfield, Mass.
1908	S. J. Wright,	39 Wall Street, Norwalk, Conn.
1909	O. B. Briggs,	1011 Fidelity Building, Baltimore, Md.
1910	F. L. Thomas,	Auburn, Ala.
1911	L. M. Johnson,	Newtown, Conn.
1912	F. S. Madison,	East Greenwich, R. I.
1913	B. W. Ellis,	575 Main Street, South Weymouth, Mass.
1914	L. Ernest Smith,	Pittsford, Vt.
1915	P. F. Whitmore,	Sunderland, Mass.
1916	Perez Simmons,	34 Boylston Street, Pittsfield, Mass.
1917	John Dizer,	– – –

DEGREES CONFERRED AND ROLL OF STUDENTS.

DEGREES CONFERRED — 1917.

MASTER OF SCIENCE (M.Sc.).

Bales, Harold Campbell, South Deerfield, Mass., Dartmouth College, A.B.
Chapin, Edward Albert, Springfield, Mass., Sheffield Scientific School, Ph.B.
Cobb, J. Stanley, Groton, N. Y., Cornell University, B.Sc.
Doran, William Leonard, North Dartmouth, Mass., Massachusetts Agricultural College, B.Sc.
Fish, Ernest Ellsworth, Wyalusing, Pa., Pennsylvania State College, B.Sc.
Merkle, Frederick Grover, Amherst, Mass., Massachusetts Agricultural College, B.Sc.
Mutkekar, Satwaji Gundoii, Belgaum, India, Poona Agricultural College, B.Agr.
Vinal, Stuart Cuningham, East Weymouth, Mass., Massachusetts Agricultural College, B.Sc.

BACHELOR OF SCIENCE (B.Sc.).

Babcock, Philip Rodney,	Lynn.
Behrend, Oswald,	Natick.
Bell, Alfred Whitney, Jr.,	West Newton.
Blake, Ralph Cedric,	Wollaston.
Boles, Robert Stewart,	Dorchester.
Bonn, Wesley Copeland,	Grafton.
Booth, Alfred,	Campbell Hall, N. Y.
Boyce, Harold Prescott,	Haverhill.
Buckman, Lewis Taylor,	Wilkes-Barre, Pa.
Buttrick, David Herbert,	Arlington.
Carruth, Glenn Howard,	Orange.
Chamberlin, Frank Shirley,	Framingham.
Clough, Charles Henry,	Dedham.
Cross, Walter Irving,	Hingham Center.
Curtin, Charles Warren,	Newton.
Davis, Monsell Henry,	Orange, N. J.
Day, James Harold,	Hatfield.
Dempsey, Paul Wheeler,	Dorchester.
Dickey, Harold Gammell,	Dorchester.
Dillon, Thomas Stevenson,	West Warren.
Dizer, John Thomas,	East Weymouth.
Duffill, Edward Stanley,	Melrose Highlands.
Dunham, Henry Gurney,	West Bridgewater.
Edwards, Franz Gill,	Beverly.
Elliot, Ralph William,	Chartley.
Everbeck, George Charles,	Boston.
Fearing, Ralph Watson,	Dorchester.
Fellows, Katharine Adelheid,	Northampton.
Fisher, George Basil,	Millbury.
Flagg, Wayne McCrillis,	Mittineague.
Flint, Oliver Simeon,	Lowell.
Goldstein, Maurice,	Lynn.
Graham, Leland Jenkins,	Amherst.
Grayson, Emory Ellsworth,	Milford.
Gurshin, Carl Alfred,	Lynn.
Hagelstein, Charles Henry,	Dorchester.
Harlow, Frank Edward,	Malden.
Harlow, Paul Goodhue,	Malden.
Henninger, Roswell Woodward,	Williamsport, Pa.
Higginbotham, Harry,	Taunton.
Holden, Richard Lynde,	Haverhill.

Holder, Ralph Clifton,	Farmington, N. H.
Hubbell, Franklin Homer,	Westport, Conn.
Irving, William Raymond,	Taunton.
Kelsey, Edmund Dean,	Amherst.
Kelsey, Lincoln David,	West Hartford, Conn.
Kinsman, Alfred Oberlin, Jr.,	Merrimac.
Larson, Frederick Christian,	Everett.
Latham, Paul Walker,	Norwichtown, Conn.
Lawrence, Milford Robinson,	Falmouth.
Light, Brooks,	Brookline.
Loring, Albert Briggs,	Nantasket Beach.
Lydiard, Harry Crowther,	Hartford, Conn.
Mack, Walter Adams,	Springfield.
MacLeod, Daniel Johnston,	Wakefield.
Marchant, Horace Greenough,	Cambridge.
Mayo, Frank Willard,	Houlton, Me.
Mayo, William Irving, Jr.,	Framingham.
McNamara, Michael Joseph,	Stoughton.
Merrill, Dana Otis,	East Pepperell.
Nash, Herman Beaman,	Amherst.
Nelson, John Brockway,	Newburyport.
Noyes, Samuel Verne,	Georgetown.
Pierce, Harold Barnard,	Hartford, Conn.
Pratt, Harold Arthur,	Shrewsbury.
Quimby, Charles Frederick,	Cape Neddick, Me.
Randall, Earle MacNeill,	Winchester.
Richardson, Lewis Elmer,	Rockville.
Rodger, Raymond Miller,	Everett.
Rogers, Roland Winsor,	Braintree.
Rorstrom, Hans Alfred,	Boston.
Ross, Louis Warren,	Boston.
Saidel, Harry Samuel,	Worcester.
Sargent, George Leonard,	Merrimac.
Saunders, William Putnam,	Lawrence.
Sauter, John Martin,	Turners Falls.
Saville, William, Jr.,	Waban.
Schaefer, Leonard Charles,	Holyoke.
Schwab, Andrew Nathan,	Yalesville, Conn.
Selkregg, Edwin Reimund,	Northeast, Pa.
Smith, Herbert Dwight,	Amherst.
Smith, Richard Woodworth,	Pittsfield.
Spaulding, Almon Whitney,	Newton Highlands.
Squires, Paul Revere,	Belchertown.
Stearns, Carlton McIntyre,	Melrose.
Stiles, Albert Ralph,	Arlington Heights.
Stowell, Harold Thurber,	Amherst.
Thayer, William Wallace,	Somerville.
Tuthill, Samuel Fuller,	Mattapoisett.
Upson, Everett Langdon,	New Britain, Conn.
Walbridge, Henry Blood,	Bennington, Vt.
Warner, Merrill Pomeroy,	Sunderland.
Warren, Harold Manson,	Melrose.
Warren, James Joseph,	North Brookfield.
Webster, Frank Cedric,	Harvard.
Westman, Robert Clayton,	Roslindale.
Whitcomb, Warren Draper,	Waltham.
Whitney, Harold Tichenor,	Mount Vernon, N. Y.
Whitney, Joseph Fradley,	Westminster.
Wies, Calmy,	Malden.
Wilber, Charles Raymond,	Walpole.
Wilcox, Timothy Palmer,	West Andover.
Williams, Arthur Franklin,	Sunderland.
Williams, Herbert Clifton,	South Hadley Falls.

ROLL OF STUDENTS.

GRADUATE STUDENTS.

Allen, Harry W., B.Sc., Massachusetts Agricultural College.	Amherst.
Bourne, Arthur I., A.B., Dartmouth College.	Amherst.
Cheplin, Harry A., B.S.A., Syracuse University.	Johnstown, Pa.
DeVault, Samuel Henry, A.B., Carson-Newman College. A.M., University of North Carolina.	Amherst.
Dougall, Robert, B.S.A., McGill University.	Pretoria, Transvaal, S. A.
Fagan, Frank N., B.Sc., Ohio State University.	State College, Pa.
Gordon, Thomas B., B.S.Agr., University of Kentucky.	Lexington, Ky.
Hompe, Louise, B.A., Smith College.	Auburn, N. Y.
Hood, Egerton Gibson, B.S.A., Toronto University.	Amherst.
Jones, Linus H., B.Sc., Massachusetts Agricultural College.	Milford.
Lieber, Conrad H., B.Sc., Massachusetts Agricultural College.	Jamaica Plain.
MacNeil, Ralph Langdel, B.Sc., Massachusetts Agricultural College.	Amherst.
Martin, John Elmer, B.S., Oklahoma Agricultural and Mechanical College.	Mounds, Okla.
Morgan, Ezra Leon, A.B., McKendree College. M.A., University of Wisconsin.	Amherst.
Mutkekar, Satwaji Gundoji, B.Agr., Poona Agricultural College. M.Sc., Massachusetts Agricultural College.	Belgaum, India.
Neill, James, B.S., Alleghany College.	Clarion, Pa.
Pauley, William C., B.Sc. in Agr., Purdue University.	Lafayette, Ind.
Peacock, Walter Miller, B.Sc., Cornell University. M.S.A., Cornell University.	Amherst.
Pontius, Byron E., B.S. in Agr., Ohio State University.	Amherst.
Porter, Bennet Allen, B.Sc., Massachusetts Agricultural College.	Amherst.
Purington, James A., B.Sc., New Hampshire College of Agriculture.	Hopkinton, N. H.
Ray, George Burrill, B.Sc., Massachusetts Agricultural College.	Hingham.
Root, Irving C., B.Sc., Kansas State Agricultural College.	Kansas City, Kan.

Serex, Paul, Jr., ... Amherst.
B.Sc., Massachusetts Agricultural College.
M.Sc., Massachusetts Agricultural College.

Stewart, Lloyd Leland, ... Amherst.
B.Sc. in Agr., Purdue University.

Thompson, W. Bradley, ... Orange, N. J.
A.B., Williams College.

White, Donald, ... Wakefield.
A.B., Harvard College.

Wildon, Carrick E., ... Melrose Highlands.
B.Sc., Massachusetts Agricultural College.

Wood, Elwin G., ... Big Fork, Mont.
B.Sc., Washington State College.

Class of 1918.

Additon, Elizabeth Emery,	Newton Center,	Draper Hall.
Babbitt, George King,	Washington, D. C.,	14 South College.
Baker, Henry Raymond,[1]	Amherst,	West Street.
Barton, George Wendell,	North Sudbury,	3 South College.
Boyd, Robert Lucius,[1]	East Lynn,	1 South College.
Bruce, Walter Griffith,	Stafford Springs, Conn.,	21 Fearing Street.
Buchanan, Walter Gray,	Chicopee,	97 Pleasant Street.
Canlett, Franklin Harwood,	Bedford,	36 North Prospect Street.
Carlson, Fred Albert,	Pittsfield,	84 Pleasant Street.
Carter, Thomas Edward,	Andover,	6 South College.
Chapman, John Alden,	Salem,	Phi Sigma Kappa.
Clark, Stewart Sandy,	Holyoke,	Chemistry Laboratory.
Cotton, Elwyn Page,	Woburn,	2 North College.
Davis, Dwight Shaw,	Woburn,	3 South College.
Edes, David Oliver Nourse,	Bolton,	Mathematics Building.
Emmerich, Louis Philip,[1]	Paterson, N. J.,	Q. T. V. House.
Foley, William Albert,	Palmer,	Alpha Sigma Phi.
Foster, Roy Wentworth,	Lynn,	Lambda Chi Alpha.
Goodwin, William Irving,[1]	Bradford,	Lambda Chi Alpha.
Haines, Foster Kingsley,	Peabody,	15 South College.
Hance, Forrest Sansbury,	Paterson, N. J.,	Theta Chi.
Hayes, Olin Henry,[1]	Lawrence,	M. A. C. Poultry Plant.
Hilliker, Harriett Franklin,[1]	East Lynn,	87 Pleasant Street.
Holmes, George Frederick,[1]	Ipswich,	60 Pleasant Street.
Howes, Donald Francis,	Ashfield,	11 North College.
Hunnewell, Paul Fiske,	Winthrop,	Phi Sigma Kappa.
Illman, Margaret Keble,	Schuyler Falls, N. Y.,	Draper Hall.
Johnson, Birger Lars,[1]	Dorchester,	Stockbridge Hall.
Lanphear, Marshall Olin,	Windsor, Conn.,	Kappa Sigma.
Lawrence, Lewis Henry,[1]	Falmouth,	83 Pleasant Street.
Lawton, Ralph Wilber,	Fall River,	3 South College.
Leonard, Ralph Stanley,	Melrose,	Lambda Chi Alpha.
Levine, Darwin Solomon,	Sherborn,	5 South College.
Lipshires, David Mathew,	Roxbury,	South College.
Loring, William Rupert,	Great Barrington,	South College.
Lyons, Louis Martin,	Boston,	East Experiment Station.
Mallorey, Alfred Sidney,[1]	Lynn,	51 Amity Street.
McRae, Herbert Rankin,	Malden,	4 Nutting Avenue.
Millard, Harold Baldwin,[1]	Great Barrington,	Veterinary Laboratory.
Mower, Carl Taft,[1]	Barre, Vt.,	Kappa Sigma.
Newton, Gaylord Arthur,	Durham, Conn.,	10 South College.
Phipps, Clarence Ritchie,[1]	Dorchester,	Theta Chi.
Popp, Edward William,	Albany, N. Y.,	13 South College.
Pratt, Oliver Goodell,	Salem,	Kappa Sigma.
Preble, John Nelson,	Jamaica Plain,	Theta Chi.
Raymond, Clinton Rufus,	Beverly,	Lambda Chi Alpha.

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[1] Work incomplete.

Reumann, Theodore Henry,	New Bedford,	12 South College.
Richardson, Stephen Morse,[1]	Wellesley,	Q. T. V. House.
Ritter, Ernest,	New Britain, Conn.,	Theta Chi.
Roberts, Oliver Cousens,[1]	Arlington,	Theta Chi.
Rosequist, Birger Reignold,	Brockton,	14 South College.
Russell, Howard Leigh,	Worcester,	Theta Chi.
St. George, Raymond Alexander,	East Lynn,	Entomology Building.
Sanborn, Dean Waldron,	Conway,	Q. T. V. House.
Sawyer, Wesley Stevens,	Boston,	7 South College.
Schlough, George Hamer,	Waltham,	Lambda Chi Alpha.
Schwartz, Louis,	Melrose,	5 South College.
Smith, Carleton Tower,	West Newton,	6 South College.
Smith, Sidney Summer,[1]	Roslindale,	South College.
Stjernlof, Axel Uno,	Worcester,	15 South College.
Sullivan, Harold Leo,	Lawrence,	13 South College.
Tilton, Arthur Dana,	Wellesley,	Phi Sigma Kappa.
van Alstyne, Lewis Morrell,[1]	Kinderhook, N. Y.,	Phi Sigma Kappa.
Wooding, Paul Bennett,[1]	Yalesville, Conn.,	French Hall.

Class of 1919.

Alden, Dean Watson,[1]	Proctor, Vt.,	82 Pleasant Street.
Bagg, Quincy Austin,[1]	South Hadley,	9 North College.
Baker, William Alphonso,[1]	Melrose,	82 Pleasant Street.
Baker, William Herbert, Jr.,	Chesterfield,	88 Pleasant Street.
Batchelder, Stewart Putnam,	North Reading,	Q. T. V. House.
Blanchard, Carlton Douglas,	Uxbridge,	Kappa Sigma.
Bögholt, Carl Miller,[1]	Newport, R. I.,	Q. T. V. House.
Bond, Herbert Richard,	Needham,	Phi Sigma Kappa.
Bowen, Arthur Newton,[1]	Quincy,	7 South College.
Bowen, Maurice Stetson,[1]	Middleborough,	81 Pleasant Street.
Boyce, Alan Freeman,	Melrose,	83 Pleasant Street.
Boynton, Raymond Woods,[1]	Framingham,	Alpha Sigma Phi.
Brigham, Sylvia Bowen,[1]	Newtonville,	Draper Hall.
Buffum, Eliot Mansfield,	Waban,	College Store.
Burt, Henry John,	Arlington,	66 Pleasant Street.
Burton, Lee Williams,	Plainville,	3 North College.
Callanan, John Edward,[1]	Dorchester,	60 Pleasant Street.
Callanan, Vincent DePaul,	Malden,	Draper Hall.
Carpenter, Hall Bryant,	Somerville,	Kappa Sigma.
Carroll, Olive Evangeline,[1]	Dorchester,	33 East Pleasant Street.
Cassidy, Morton Harding,[1]	East Boston,	Lambda Chi Alpha.
Chandler, Arthur Lincoln,	Leominster,	12 South College.
Chapin, Frederic Charles,	Greenfield,	West Experiment Station.
Chase, Malcolm Willis,[1]	Amesbury,	94 Pleasant Street.
Chisholm, Robert Dudley,[1]	Melrose Highlands,	Phi Sigma Kappa.
Coderre, Ernest Laurier,	Southbridge,	Alpha Sigma Phi.
Collins, Robert Burleigh,	Rockland,	88 Pleasant Street.
Cosby, Alfred Francis,	Westfield,	15 Amity Street.
Crowe, Charles,[1]	Norwich, Conn.,	Kappa Sigma.
Day, Harold Ralph,	Milford,	Alpha Sigma Phi.
Dickinson, Victor Abel,[1]	Amherst,	Mount Pleasant.
Dunbar, Charles Oliver,[1]	Westfield,	84 Pleasant Street.
Erhard, Bena Gertrude,[1]	East Milton,	Draper Hall.
Erickson, Gunnar Emmanuel,	West Lynn,	9 South College.
Evans, Myrton Files,	West Somerville,	Kappa Sigma.
Faneuf, Ambrose Clement,[1]	West Warren,	Chemistry Laboratory.
Farrington, Robert Pierce,[1]	Nantucket,	15 Beston Street.
Faxon, Paul,[1]	Wellesley Hills,	Phi Sigma Kappa.
Ferris, Adaline Lawson,	Ridgefield Park, N. J.,	Draper Hall.
Ferriss, Samuel Boynton,[1]	New Milford, Conn.,	11 North College.
Field, Wilbert Daniel,[1]	Winter Hill,	29 McClellan Street.

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[1] Work incomplete.

Fogg, Verne Allen,	Topsfield,	73 Pleasant Street.
French, Willard Kyte,	Worcester,	Q. T. V. House.
Garde, Earl Augustus,	Lynn,	30 North Prospect Street.
Garvey, Mary Ellen Monica,	Amherst,	27 South Prospect Street.
Glavin, William Francis,	Wenham,	North College.
Goff, Howard Mason,	Cambridge,	Phi Sigma Kappa.
Green, Lynn,[1]	Schenevus, N. Y.,	53 Lincoln Avenue.
Guba, Emil Frederick,	New Bedford,	Clark Hall.
Hall, Frank Edwin,[1]	Revere,	Lambda Chi Alpha.
Harris, Ethel Lovett,[1]	Beverly,	Draper Hall.
Hartwell, Richard Raymond,[1]	Springfield,	Colonial Inn.
Hastings, Louis Pease,	Springfield,	Kappa Sigma.
Hodgson, Benjamin Earl,	Methuen,	M. A. C. Farm House.
Hopkins, George Randolph Lawrence.	Orleans,	116 Pleasant Street.
Howe, Ralph Thomas,	Melrose Highlands,	120 Pleasant Street.
Hunter, Harold Clayton,[1]	South Hadley Falls,	9 South College.
Jewell, Charles Henry,	Merrimac,	M. A. C. Farm House.
Johnson, Lawrence Wilhelm,	Avon,	Alpha Sigma Phi.
Johnson, Sidney Clarence,[1]	Gloucester,	7 South College.
Jordan, Raymond Douglas,[1]	Springfield,	9 South College.
Knight, Frank Edward,[1]	Brimfield,	3 North College.
Knowlton, Priscilla,[1]	Roxbury,	87 Pleasant Street.
Liebman, Anna,	Dorchester,	Draper Hall.
Mansell, Elton Jessup,[1]	Cambridge,	Phi Sigma Kappa.
Mather, William,	Amherst,	West Experiment Station.
Mattoon, Charles Gordon,	Pittsfield,	2 North College.
McCarthy, Arthur Martin,	Monson,	Q. T. V. House.
Morse, Maurice,	Dorchester,	Entomology Building.
Morton, Elmer Joshua,[1]	Watertown,	Veterinary Laboratory.
Newbold, Douglas Tracy,	Northampton,	16 South College.
O'Hara, Joseph Ernest,[1]	Worcester,	8 Kellogg Avenue.
Parke, Robert Warren,	Winchendon,	1 Allen Street.
Parkhurst, Raymond Thurston,	Fitchburg,	Kappa Sigma.
Parsons, Edward Field,	North Amherst,	North Amherst.
Peck, George Newberry,	Granville,	9 South College.
Peirson, Henry Byron,	New Bedford,	Kappa Sigma.
Perry, Errol Clinton,[1]	Acushnet,	15 Hallock Street.
Peterson, Leroy Duane,[1]	Brooklyn, N. Y.,	85 Pleasant Street.
Pierpont, Frederick Trowbridge,	Stamford, Conn.,	18 Nutting Avenue.
Prée, Karl Julius,	Brookline,	88 Pleasant Street.
Pulley, Marion Gertrude,[1]	Melrose,	2 Allen Street.
Rea, Julian Stuart,	East Weymouth,	15 Beston Street.
Record, Harold Jordan,	West Boylston,	73 Pleasant Street.
Ross, Donald,	Boston,	Phi Sigma Kappa.
Rowe, Clifford Alton,[1]	East Orange, N. J.,	Phi Sigma Kappa.
Sargent, Walter Harriman,[1]	Malden,	4 Chestnut Street.
Sibley, Helen Aramintha,[1]	Longmeadow,	Draper Hall.
Skinner, Everett Hamilton,[1]	West Upton,	Kappa Sigma.
Smith, Wendell Frederick,[1]	Troy, N. Y.,	66 Pleasant Street.
Spaulding, Harold Edwin,[1]	Milford,	Aggie Inn.
Stafford, Irving Boynton,	Fall River,	6 Nutting Avenue.
Stevens, Chester Dillingham,	Reading,	120 Pleasant Street.
Stockwell, Ervin Sidney, Jr.,[1]	Sharon,	81 Pleasant Street.
Strack, Edward,[1]	Framingham,	Clark Hall.
Sutherland, Ralph,[1]	Cambridge,	13 South College.
Sweeney, William Joseph,	Dorchester,	North College.
Taylor, Edmund Billings,	Wollaston,	13 Phillips Street.
Thayer, Weston Cushing,[1]	Hingham,	1 South College.
Thomas, Frank DesAutels,[1]	Milford,	1 North College.
Tirrell, Loring Vinson,	South Weymouth,	Theta Chi.
Underwood, Arthur Leslie,[1]	Maynard,	11 North College.

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[1] Work incomplete.

Vickers, John,[1]	Amherst,	90 Pleasant Street.
Wells, Marion Nichols,	Springfield,	Draper Hall.
White, Edward Asa,	Providence, R. I.,	11 South College.
Whittle, Clarence Parker, Jr.,[1]	Weymouth,	Phi Sigma Kappa.
Williams, Kenneth Sanderson,[1]	Sunderland,	Q. T. V. House.
Window, James Joseph,	Springfield,	5 Allen Street.
Wood, Oliver Wiswell,[1]	Arlington,	81 Pleasant Street.
Woodard, Chester Smith,[1]	Leverett,	Leverett.
Woodbury, Ray Willard,[1]	Newburyport,	Cottage Street.
Woodside, Wilfred Livingstone,	Boston,	73 Pleasant Street.
Yesair, John,[1]	Byfield,	Kappa Sigma.

Class of 1920.

Allen, Harold Kenneth,	Belchertown,	100 Main Street.
Andrews, George Henry,[1]	Farmington, Conn.,	1 School Street.
Apsey, George Wills, Jr.,	Winchester,	85 Pleasant Street.
Armstrong, Philip Brownell,	Rutherford, N. J.,	Phi Sigma Kappa.
Bacon, Milo Roderick,[1]	Leominster,	Draper Hall.
Bailey, William, Jr.,	Williamstown,	M. A. C. Farm House.
Ball, Harry Abraham,	Bridgewater,	16 North College.
Ball, Lorin Earl,[1]	Amherst,	3 Allen Street.
Beauregard, Winfield Scott,	Framingham,	15 North College.
Belcher, Daniel Webster,[1]	North Easton,	120 Pleasant Street.
Berman, Harry,[1]	Holyoke,	5 South College.
Berman, Louis,[1]	Dorchester,	9 Fearing Street.
Bigelow, Henry Charles,	Millville, N. J.,	90 Pleasant Street.
Blanchard, Kenneth,[1]	Highland Falls, N. Y.,	5 Nutting Avenue.
Boardman, Charles Meade,	Amherst,	33 Lincoln Avenue.
Brown, Roy Robertson,	Hudson,	Physics Building.
Bunker, Carroll Wooster,	West Somerville,	Q. T. V. House.
Burns, Allan Melville, Jr.,	Taunton,	88 Pleasant Street.
Campbell, George Murray,[1]	Baltimore, Md.,	Phi Sigma Kappa.
Cande, Robert Parsons,	Pittsfield,	23 East Pleasant Street.
Card, Ralph Hunter,	Somerville,	Cottage Street.
Carleton, John Foxcroft,	East Sandwich,	Draper Hall.
Center, Arthur Edwin,	Springfield,	73 Pleasant Street.
Clarridge, Fred William,	Milford,	88 Pleasant Street.
Clough, Alfred Arnold,	Wollaston,	Physics Building.
Cole, Frederick Eugene, Jr.,	South Portland, Me.,	88 Pleasant Street.
Crafts, Gordon Burnham,	Manchester,	Q. T. V. House.
Crawford, John Alexander,	Allston,	90 Pleasant Street.
Crimmin, Royce Brainerd,[1]	Bradford,	Lambda Chi Alpha.
Daggett, Clinton Jones,	Washington, D. C.,	Kappa Sigma.
Davenport, Frank Semore,[1]	Dorchester,	Alpha Sigma Phi.
Davidson, Donald Gordon,	Amherst,	7 Northampton Road.
Davis, Orrin Chester,	Belchertown,	90 Pleasant Street.
Delahunt, John Kersey,	Boston,	29 McClellan Street.
Derick, Glendon Robert,	Clinton,	13 Phillips Street.
Dewing, Warren Montague,	Kingston,	Kappa Sigma.
Doucette, Charles Felix,	Melrose,	M. A. C. Apiary.
Douglass, Donald Churchill,[1]	Cambridge,	Phi Sigma Kappa.
Dwyer, James Edward,	Sunderland,	Alpha Sigma Phi.
Earley, Marion Edith,[1]	West Newton,	87 Pleasant Street.
Emery, Herbert Martin,[1]	Newburyport,	5 North College.
Faber, Edward Stuart,[1]	Plainfield, N. J.,	77 Pleasant Street.
Farnsworth, Richard Wasgatt,[1]	Lancaster,	1 School Street.
Fuller, Lorenzo,	Lowell,	Lambda Chi Alpha.
Graff, Leland Sprague,[1]	Reading,	66 Pleasant Street.
Graves, Carlisle Ferrin,	Stamford, Conn.,	Alpha Sigma Phi.
Gray, Irving Emery,[1]	Woods Hole,	90 Pleasant Street.
Grout, Nathan,[1]	Sherborn,	60 Pleasant Street.

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[1] Work incomplete.

Hale, Frank Thompson Caldwell,[1]	Byfield,	90 Pleasant Street.
Hamlin, Hazen Wolcott,[1]	Amherst,	90 Pleasant Street.
Harrington, Harold Leon,	Lunenburg,	44 Triangle Street.
Haslam, Emerson Francis,	Westwood,	101 Pleasant Street.
Haynes, Charles Francis,[1]	Canton,	13 Phillips Street.
Higgs, John Alden,[1]	Wareham,	120 Pleasant Street.
Hill, John Farren,	Egypt,	29 McClellan Street.
Hill, Theodore, Jr.,[1]	Jefferson Valley, N. Y.,	Lambda Chi Alpha.
Holland, Frank Harold,	Shrewsbury,	Plant House.
Holloway, John William,	Taunton,	5 Nutting Avenue.
Holmes, John Foster,	Needham,	Lambda Chi Alpha.
Horne, Robert Sanderson,[1]	Wellesley Farms,	Q. T. V. House.
Hurd, Davis Alden,[1]	Wellesley Hills,	36 North Prospect Street.
Hurd, Gordon Killam,[1]	Millbury,	36 North Prospect Street.
Iorio, Carlo Antonio,	Springfield,	75 Pleasant Street.
Jakeman, Brooks Franklin,	Winchester,	Lambda Chi Alpha.
Johnson, Conrad John,	Campello,	Lambda Chi Alpha.
Jones, Robert Lambert,	North Easton,	Q. T. V. House.
King, William Cutting,	Suffield, Conn.,	120 Pleasant Street.
Lambert, Richard Bowles,	Gleasondale,	Mathematics Building.
Lent, Donald Ashford,	Maynard,	90 Pleasant Street.
Levine, Maurice Eleazer,[1]	Sherborn,	10 North College.
Littlefield, John Edwin,	Lynn,	15 Hallock Street.
Lothrop, Earle Daniel,	West Bridgewater,	90 Pleasant Street.
Luce, William Alan,	West Boylston,	Lambda Chi Alpha.
Lyons, Henry Egmont,[1]	Boston,	East Experiment Station.
MacArdle, Herbert Aloysius,[1]	Worcester,	7 North College.
MacLeod, Guy Franklin,[1]	Lowell,	14 South College.
Mallon, Charles Hugh,	East Braintree,	Phi Sigma Kappa.
Maples, James Comly,	Port Chester, N. Y.,	81 Pleasant Street.
Martin, Laurence Paul,	Malden,	5 Allen Street.
McNulty, Raymond Henry,[1]	Amherst,	6 South East Street.
Meserve, Albert Wadsworth,	Framingham,	6 North College.
Millard, Helen Stanley,	Great Barrington,	Draper Hall.
Newell, Philip Sanger,	West Newton,	Phi Sigma Kappa.
Oppe, Herman DeWitt,[1]	Sandy Hook, Conn.,	94 Pleasant Street.
Peckham, William Harold,[1]	Newport, R. I.,	Alpha Sigma Phi.
Quadland, Howard Preston,	North Adams,	2 North College.
Readio, Philip Adna,	Florence,	90 Pleasant Street.
Redding, George Kenneth,	Melrose,	9 Fearing Street.
Reed, Morris,[1]	Worcester,	77 Pleasant Street.
Richards, George Henry,[1]	Springfield,	Phi Sigma Kappa.
Robertson, William Fenton,[1]	Framingham,	6 North College.
Sanborn, Joseph Raymond,	North Amherst,	North Amherst.
Sanderson, Ralph Hemenway,	Waltham,	18 Nutting Avenue.
Schandelmayer, Ralph Ernest,	Hudson,	Stockbridge Hall.
Scott, Clifton William,	Buckland,	17 Phillips Street.
Shattuck, Carl Winter,[1]	Jamaica Plain,	M. A. C. Farm House.
Shaughnessy, Howard John,	Easthampton,	17 Phillips Street.
Simmons, Lester Winslow,	Dighton,	75 Pleasant Street.
Smith, Donald Hiram,	Pittsfield,	23 East Pleasant Street.
Smith, Fred George,	Gardner,	3 High Street.
Smith, George Alfred,	Whitinsville,	Q. T. V. House.
Smith, Raymond Newton,[1]	Plainville,	3 North College.
Smith, Susan Almira,	Great Barrington,	Care of E. F. Gaskill.
Snow, John Dow,[1]	Arlington,	Phi Sigma Kappa.
Spencer, William,[1]	Worcester,	9 Fearing Street.
Stedman, Ralph Shaw,[1]	Springfield,	Phi Sigma Kappa.
Stiles, William Burling,	Great Barrington,	Lambda Chi Alpha.
Strecker, Edmund Herman,[1]	New York City,	Q. T. V. House.
Sullivan, Walter Mitchell,[1]	Lawrence,	14 South College.

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[1] Work incomplete.

Sweeney, Frank Joseph,[1]	Whitman,	35 Hallock Street.
Taylor, Elliot Hubbard,[1]	Shelburne,	Q. T. V. House.
Taylor, Thornton Greenwood,[1]	Winchester,	Lambda Chi Alpha.
Urquhart, John Wardrop,	East Walpole,	29 McClellan Street.
Vigezzi, Mary Theresa,[1]	Great Barrington,	Draper Hall.
Williams, Allan Carruth,	Rockland,	16 North College.
Woodward, Ralph, Jr.,[1]	Grafton,	Colonial Inn.
Wright, Stuart Eldridge,	Raynham,	Kappa Sigma.

Class of 1921.

Alexander, Ralph Elmer,	Lynn,	17 Pleasant Street.
Alger, James Warren,[1]	Reading,	120 Pleasant Street.
Allen, Henry Vaughn,	Arlington,	7 Nutting Avenue.
Ames, Nathaniel Jackson,	Peabody,	81 Pleasant Street.
Andersen, Charles Henry,	Medford,	6 Nutting Avenue.
Baker, Louis Eliot,[1]	Salem,	41 Pleasant Street.
Baker, Russell Dexter,	Marshfield,	5 Allen Street.
Bartlett, John Lloyd Burnham,[1]	Westborough,	36 North Prospect Street.
Bennett, James Stanley,	South Meriden, Conn.,	3 Nutting Avenue.
Blackwell, Henrietta,	Boston,	North Amherst.
Blessington, James Bernard,	Lynn,	– –
Bowen, Willard Lee, Jr.,[1]	Natick,	North Amherst.
Brigham, John Dexter,	Sutton,	75 Pleasant Street.
Brown, Charles Henry,	Winthrop,	77 Pleasant Street.
Brown, Paul Bromby,	Brockton,	116 Pleasant Street.
Brown, Paul Wilfred,[1]	Fiskdale,	75 Pleasant Street.
Buck, Horace Gould,[1]	Easton,	120 Pleasant Street.
Calhoun, Saitean Frederick,	Brookline,	73 Pleasant Street.
Cameron, Viola Mary,[1]	Pelham,	East Pleasant Street.
Cascio, Peter Joseph,[1]	Willimantic, Conn.,	7 Nutting Avenue.
Channell, Frederick Charles,[1]	Winthrop,	35 North Prospect Street.
Chaquarian, George A.,[1]	Haverhill,	– –
Cook, Donald Homer,	Hadley,	Hadley.
Coombs, Roger Conklin,	Peabody,	M. A. C. Farm House.
Cooper, Lawrence Melville,	Charlemont,	36 North Prospect Street.
Day, Roland Wight,	Medfield,	83 Pleasant Street.
Dean, Herman Nelson,	Oakham,	90 Pleasant Street.
Edman, George William,	Orange,	4 Nutting Avenue.
Evers, Joseph Daniel,[1]	Malden,	Draper Hall.
Fenton, James Francis,	Amherst,	108 Pleasant Street.
Fisher, Leander Winsor,	Lynn,	31 East Pleasant Street.
Fletcher, Francis Summers,[1]	East Lynn,	31 East Pleasant Street.
Fogg, Lloyd Clarke,	Topsfield,	73 Pleasant Street.
Freeman, Stanley Leonard,[1]	Needham,	5 Nutting Avenue.
French, Carroll Brackett,	Lynn,	Corner Fearing Street and Lincoln Avenue.
Galusha, Mark Hampton,	Williamstown,	90 Pleasant Street.
Gaskill, Harland Everett,	Hopedale,	North Pleasant Street.
Geer, Herbert Leroy,	Three Rivers,	23 East Pleasant Street.
Goodstone, Sarah Winthrop,	Springfield,	11 South Prospect Street.
Gould, Robert Meredith,	Shelburne,	6 Nutting Avenue.
Hallett, Melvin Bernard,	Rockland,	5 Fearing Street.
Haskins, Harold Arthur,	North Amherst,	North Amherst.
Hathaway, Warren Sidney,[1]	Somerset,	Draper Hall.
Hayes, Elmer Russell,[1]	Somerville,	– –
Hemenway, Rachel Viola,[1]	Williamsburg,	Draper Hall.
Hodgson, Robert Moore,[1]	Newport, R. I.,	The Davenport.
Howard, Frederic,	Needham,	5 Nutting Avenue.
Howard, Winthrop Wilmarth,	South Easton,	29 North Prospect Street.
Kendall, Charles Donald,	Worcester,	83 Pleasant Street.
Kirkland, Lyle Lord,[1]	Chester,	77 Pleasant Street.

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[1] Work incomplete.

Kokoski, Frank Joseph,	Hadley,	R. F. D. 3, Box 112.
Labrovitz, Edward Browdy,	Amherst,	11 Amity Street.
Lacroix, Donald Sewall,[1]	Newbury,	116 Pleasant Street.
Leavitt, Ralph Goodwin,	Melrose,	6 Nutting Avenue.
Lewandowski, John,[1]	Easthampton,	17 Phillips Street.
Lockwood, George Russell,	Hyde Park,	101 Pleasant Street.
Long, Albert Douglas,	Chicopee,	23 East Pleasant Street.
Lovering, Rolland Frederick,[1]	Northampton,	283 Prospect Street, Northampton.
Lyon, William Henry,[1]	Lexington,	120 Pleasant Street.
Mackintosh, Charles Gideon,	Peabody,	81 Pleasant Street.
Marsh, Walter Ashton,[1]	Holden,	31 East Pleasant Street.
Martin, Edward William,	Amherst,	19 South East Street.
McCarthy, Justin Jerimiah,[1]	Arlington,	Colonial Inn.
Meister, John Jacob,[1]	Dorchester,	7 Nutting Avenue.
Mellen, Richard Adams,[1]	Cambridge,	116 Pleasant Street.
Miller, Charles Norman,[1]	Chatham, N. J.,	16 Nutting Avenue.
Miller, William Henry,	Springfield,	120 Pleasant Street.
Millington, Walter Roy,	Maynard,	21 Amity Street.
Mutty, Allan Victor,	Melrose,	4 Chestnut Street.
Nuber, Ralph Everson,	Washington, D. C.,	77 Pleasant Street.
Palmer, Walter Isaiah,[1]	Amherst,	4 Chestnut Street.
Park, Francis Edwin, Jr.,	Stoneham,	Mount Pleasant.
Peck, Richard Charles,	Shelburne,	6 Nutting Avenue.
Platt, Charles Wilbur,[1]	Newtown, Conn.,	94 Pleasant Street.
Pratt, Laurence Francis,	North Weymouth,	75 Pleasant Street.
Preston, Everett Carroll,[1]	Dorchester,	2 Allen Street.
Quint, Isador Gabriel,	Roxbury,	41 Pleasant Street.
Reed, Paul Malcolm,	Baldwinsville,	75 Pleasant Street.
Reynolds, Francis Curtis,[1]	Hadley,	9 Phillips Street.
Rice, Henry Lawrence,[1]	Somerville,	4 Nutting Avenue.
Richardson, Marjory,[1]	Millis,	Draper Hall.
Richardson, Raymond Bradbury,	Brookline,	Care of Mrs. Fearing, Pleasant Street.
Robertson, Lafayette Janes,	Hartford, Conn.,	116 Pleasant Street.
Robinson, Philip Luther,	New Bedford,	66 Pleasant Street.
Rogers, Charles Beatley,	Malden,	21 Fearing Street.
Rosoff, Samuel,	Springfield,	41 Pleasant Street.
Russell, Charles Francis,	Winchendon,	1 Allen Street.
Russert, Marion Ruth,[1]	Roxbury,	Draper Hall.
Sanford, Richard Herbert,[1]	Westfield,	29 North Prospect Street.
Slate, George Lewis,[1]	Bernardston,	4 Chestnut Street.
Sloan, Kenneth Wilson,[1]	Amherst,	29 North Prospect Street.
Smith, Julian Denton,	Far Rockaway, N. Y.,	90 Pleasant Street.
Spencer, Orville Holland,	West Haven, Conn.,	101 Butterfield Avenue.
Starkey, Robert Lyman,	Fitchburg,	7 Nutting Avenue.
Stebbins, Frederick Osborne,	Deerfield,	120 Pleasant Street.
Stevens, Ralph Shattuck,[1]	Arlington,	Colonial Inn.
Stiles, Harry Stephen,	Lynn,	3 Nutting Avenue.
Stinson, Elton Salem,	Nampa, Idaho,	30 North Prospect Street.
Stockbridge, John Sylvester,	Atlanta, Ga.,	Kappa Sigma.
Thyberg, George Jonathan,	Springfield,	9 Fearing Street.
Tillson, Reginald Drury,	Whitman,	21 Fearing Street.
Van Lennep, Emily Bird,	Great Barrington,	21 Amity Street.
Webster, Milton Fuller,[1]	Malden,	73 Pleasant Street.
West, Guy Clifford,	Amesbury,	5½ Tillson Court.
Whittle, Wallace Lovering,	Weymouth,	13 Phillips Street.
Wilson, Charles William Schragey, Jr.[1]	New Rochelle, N. Y.,	66 Pleasant Street.
Wood, Clarence Milton,	Somerville,	90 Pleasant Street.
Zercher, Frederick Kaupp,	Jersey City, N. J.,	21 Amity Street.

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[1] Work incomplete.

Probation.

Davol, Percy Wilfred,[1]	Brockton,	5 Farview Way.
Hastings, John Walter,[1]	Cliftondale,	36 North Prospect Street.
Jacobs, Albert Fullerton,[1]	Webster,	120 Pleasant Street.
Kile, Trueman Eugene,[1]	Providence, R. I.,	77 Pleasant Street.
Kroeck, Julius, Jr.,[1]	Brooklyn, N. Y.,	7 Nutting Avenue.
McCormack, Ralph Roby,[1]	West Somerville,	36 North Prospect Street.
Rice, Gordon Alexander,[1]	Jamaica Plain,	7 Nutting Avenue.
Sampson, Howard Jenney,[1]	Fall River,	Butterfield Avenue.
Sandy, Cecil Henry,[1]	Worcester,	60 Pleasant Street.
Vinten, Charles Raymond,[1]	Roxbury,	116 Pleasant Street.

UNCLASSIFIED STUDENTS.

Anderson, Gust William,	Brockton,	9 Fearing Street.
Austin, Walter Patrick,	Pittsfield,	120 Pleasant Street.
Blanchard, Margery Elizabeth,	Linwood,	87 Pleasant Street.
Burt, John Holton,	Hyde Park,	Care of E. M. Dickinson.
Burt, Richard Bartlett,	Hyde Park,	Care of E. M. Dickinson.
Carlson, Walter Mauritz,	Northborough,	Care of C. H. Thompson.
Conant, Luman Binney,	Waltham,	18 Nutting Avenue.
Crosby, Robert Francis,	Methuen,	31 East Pleasant Street.
Culver, Roger Lewis,	Williamsburg,	– –
Davis, Edwin John,	Holyoke,	Aggie Inn.
DeCouagne, Alfred Joseph,	Holyoke,	– –
Eastwood, John Edgar,	Plymouth,	81 Pleasant Street.
Fox, Stanley Richardson,	Dracut Center,	M. A. C. Farm House.
Fuller, Carroll Edward,	Portland, Me.,	Kappa Sigma.
Geoghegan, James Dewey,	Brighton,	5 Sunset Avenue.
Gerrish, Arthur Hermon,	Lowell,	35 North Prospect Street.
Gidney, Paul Donald,	Orange,	Care of B. F. Waid, Amity Street.
Goodhue, Joseph Gale,	Haydenville,	116 Pleasant Street.
Green, Howard Emery,	Westfield,	31 East Pleasant Street.
Hansen, Ernest,	Worcester,	18 Nutting Avenue.
Hibbard, Harry Benjamin, Jr.,	Dorchester,	4 Chestnut Street.
Hugo, Alvin Ernest,	Worcester,	36 North Prospect Street.
Humeston, Raymond Frederick,	Holyoke,	The Davenport.
Jones, Edward Charles,	Wrentham,	7 Nutting Avenue.
Kimball, Everett Foster,	Littleton,	35 North Prospect Street.
Marquedant, Isabel,	Grass Lake, Mich.,	79 Pleasant Street.
Mattoon, Max Watkins,	Pittsfield,	120 Pleasant Street.
Morris, Earle Leslie,	Springfield,	60 Pleasant Street.
Neill, Fred Alexander,	Clarion, Pa.,	15 Phillips Street.
Noble, Theodore Kingsbury,	New London, Conn.,	M. A. C. Farm House.
Novitski, Joseph Francis,	Amherst,	30 Cottage Street.
Pollard, Jane Isabel,	North Adams,	Draper Hall.
Prouty, Alfred Howe,	Spencer,	53 Lincoln Avenue.
Robinson, Harry Judson,	Taunton,	Care of E. M. Dickinson.
Robinson, Nathan Hale,	Braintree,	77 Pleasant Street.
Samuel, Dorothea,	Mount Airy, Pa.,	79 Pleasant Street.
Shannon, Mary,	Chester,	39 East Pleasant Street.
Stockbridge, Derry Lamal,	Atlanta, Ga.,	Kappa Sigma.
Strong, John Robert,	Pittsfield,	120 Pleasant Street.
Studley, Joshua,	Rockland,	5 Fearing Street.
Tanner, Willis,	Yokohama, Japan,	3 McClure Street.
Thompson, George Henry, Jr.,	Lenox,	4 Nutting Avenue.
Trulson, George Frederick,	Worcester,	3 Nutting Avenue.
Watson, Hawkesworth Douglas,	Walpole,	23 East Pleasant Street.
Waugh, Dorothy,	Amherst,	M. A. C.
Webber, Karl Durrell,	West Wrentham,	7 Nutting Avenue.

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[1] Work incomplete.

Wheeler, William Edwin,	Bolton,	53 Lincoln Avenue.
White, George Edwin,	Worcester,	60 Pleasant Street.
Wing, Philip Henry,	North Grafton,	3 McClure Street.
Wright, Whitcomb Wadleigh,	Lowell,	35 North Prospect Street.

SPECIAL STUDENTS.

Cole, Robert Henry,	Three Rivers,	– –
Holland, Dorothy FitzGerald,	Summit, N. J.,	Mount Holyoke College.
Samper, Edward,	Colombia, S. A.,	3 Fearing Street.
Samper, Santiago,	Colombia, S. A.,	3 Fearing Street.

VOCATIONAL POULTRY STUDENTS.

Baker, Howard William,	Wollaston,	5 Allen Street.
Brett, John Edward,	Pittsfield,	Aggie Inn.
Cleaver, Charles Leroy,	Hingham Center,	The Davenport.
Cook, John Herbert,	South Dartmouth,	8 Allen Street.
Tuttle, Kenneth Washburn,	Warren,	4 Chestnut Street.

GEOGRAPHICAL SUMMARY.

Massachusetts,	424
Connecticut,	19
New York,	14
New Jersey,	11
Pennsylvania,	5
Indiana,	1
Rhode Island,	5
District of Columbia,	3
Maine,	2
Vermont,	1
Georgia,	2
Michigan,	1
New Hampshire,	1
Idaho,	1
Kansas,	1
Kentucky,	1
Maryland,	1
Montana,	1
Oklahoma,	1
Colombia, S. A.,	2
Japan,	1
India,	1
South Africa, Transvaal,	1
Total,	500

SUMMARY BY CLASSES.

Graduate students,	29
Senior class, 1918,	64
Junior class, 1919,	113
Sophomore class, 1920,	117
Freshman class, 1921,	108
Probation freshman,	10
Unclassified students,	50
Special students,	4
Vocational poultry students,	5
Total registration,	500

SHORT COURSE STUDENTS, 1917.

THE TEN WEEKS' COURSE.

Aldrich, Leon F.,	Northampton.
Anderson, Ernest E.,	49 Marion Street, Medford.
Andrews, Nelson J.,	Amherst.
Armitage, Martin,	Gardner.
Bates, Richard,	West Medford.
Beal, Francis G.,	West Newton.
Bennett, Rosamond,	Auburndale.
Bent, Lawrence,	Watertown.
Bergmann, Col. C.,	West Toledo, Ohio.
Bergmann, Vincent,	West Toledo, Ohio.
Bradway, J. Leonard,	Monson.
Brett, John E.,	Pittsfield.
Briggs, Kenneth R.,	Wollaston.
Brown, Fred H.,	Melrose.
Brown, Lloyd A.,	Framingham.
Brown, Philip S.,	Swansea.
Buck, Paul T.,	Amherst.
Burcker, Wilhelm J.,	Englewood, N. J.
Butterfield, Wm. H.,	Brimfield.
Capen, Frank H.,	Stoughton.
Carter, Earl,	Boston.
Chamberlin, Marion,	Newton Center.
Churchill, Oliver C.,	West Somerville.
Cobb, Robert C.,	Chestnut Hill.
Coleman, Moses M.,	Mendon.
Cotter, James P.,	Salem.
Crawley, Melita,	Brookline.
Crockatt, Ernest,	Mount Hermon.
Crowley, William,	Suffield, Conn.
Crowell, B. P.,	Claremont, N. H.
Cushman, Burt A.,	Bernardston.
Danziger, Milton,	Washington, D. C.
Davenport, Vernon B.,	Orange.
Dow, Leon F.,	Livermore Falls, Me.
Dunham, B. K.,	Springfield.
Dwyer, J. Marcus,	Sunderland.
Fitzgerald, A. J.,	Braintree.
Foster, Charles H.,	North Andover.
Fox, Archer D.,	Amherst.
Gartin, Arthur,	Chestnut Hill.
Garvin, James,	Wrentham.
Gidney, Donald,	Orange.
Gilchrest, John G.,	Lunenburg.
Green, Howard W.,	Mount Hermon.
Gremmels, Charles E.,	West New Brighton, N. Y.
Gurdy, Elbert O.,	Lawrence.
Gustafson, Gustaf,	Springfield.
Gustafson, Paul E.,	Springfield.
Hallock, Genevieve,	Westborough.
Hammond, Frank,	Brookline.

Hassan, Sam,	Foxborough.
Herzog, Alfred C.,	Jersey City, N. J.
Hires, Linda S.,	Haverford, Pa.
Jackson, Henry T.,	Marlborough.
Jackson, Herbert A.,	North Amherst.
Jauncy, William,	Groton.
Kallis, Onnie S.,	Middlefield.
Kneeland, Karl W.,	Medfield.
La Point, Wilfred J.,	Amherst.
Lawley, Edith S.,	Amherst.
Logan, Nellie A.,	South Sudbury.
Lovenberg, Albert M.,	Putney, Vt.
MacGown, Ralph S.,	Sharon.
Marchant, Arthur L.,	Edgartown.
McIntyre, James B.,	Easthampton.
McWhinnie, John,	Boston.
Millington, Olive E.,	Wilmington, Vt.
Naughton, John,	Springfield.
Neleber, Benjamin,	Colchester, Conn.
Neleber, Louis,	Colchester, Conn.
Nelson, Hilman S.,	Roslindale.
Newton, Ernest L.,	Shrewsbury.
Newton, Orlo W.,	Amherst.
Ogden, Karl B.,	Winchester.
Ortloff, Henry S.,	Newton Center.
Parker, Orlo P.,	Brimfield.
Parks, Leroy B.,	Suffield, Conn.
Pearson, Franklin B.,	Fair Haven, Vt.
Pease, Robert S.,	Chester.
Prentiss, Russell I.,	Lexington.
Putnam, Avery W.,	Rutland.
Randolph, L. Fitz,	Arlington.
Rix, Anson F.,	Lawrence.
Roark, Joseph,	West Chelmsford.
Ryan, Frank J.,	West Newton.
Samaniego, Luis,	Antrim, N. H.
Savage, John B.,	Amherst.
Scott, J. Edmund,	Amherst.
Seaverns, Annie W.,	Jamaica Plain.
Seshong, Harold A.,	Campello.
Shumway, Alvah,	Florence.
Smith, Elmer D.,	Cheshire, Conn.
Smith, Howard C.,	Worcester.
Snow, Richard L.,	Brockton.
Southwick, L. H.,	Williamstown.
Stumpp, Robert E.,	Greenwich, Conn.
Tinker, Arthur A.,	Stamford, Conn.
Totman, Richard J.,	Conway.
Turner, Alfred W.,	Amherst.
Tuttle, Arthur E.,	Turners Falls.
Vincent, Edward,	Amherst.
Whitcher, George S.,	Atlantic.
Whiting, Henry T.,	Berkshire.
Whitney, Edmund,	Maynard.
Wickman, Irving G.,	Springfield.
Wilcox, G. Burton,	Manchester, Vt.
Winter, Oliver A.,	West Roxbury.
Wood, Harry E.,	Beverly.
Woodward, Leslie M.,	Saxonville.
Wright, Daniel H.,	Bartonsville, Vt.
Wright, Warren B.,	Amherst.

Summer School of Agriculture and Country Life.

Armstrong, Anna R.,	Rutherford, N. J.
Armstrong, Marian,	Rutherford, N. J.
Barker, Mary H.,	Worcester.
Barnard, Seymour,	Brooklyn, N. Y.
Barrett, Frances,	Adams.
Bayley, Louise,	Peacham, Vt.
Bealer, Elizabeth R.,	Jamestown, N. Y.
Bell, Mary V.,	Sharon.
Bourne, Edith L.,	Arlington.
Boynton, Anna L.,	Pepperell.
Bradley, Ruth J.,	Springfield.
Buell, Grace,	Wellesley Hills.
Butler, Gertrude M.,	Douglaston, N. Y.
Butler, Marianne E.,	Douglaston, N. Y.
Carlton, Mrs. Josephine,	Springfield.
Clarke, Elizabeth L.,	Williamstown.
Cooper, M. Claire,	South Boston.
Cotton, Edith F.,	Malden.
Cutting, Alice,	Waltham.
Cutting, Miss M. E.,	Middlebury, Conn.
Dame, Daisy G.,	West Medford.
Darrow, Ruth,	Cherokee, Iowa.
Davis, Elizabeth I.,	Taunton.
Davis, Mabel,	Auburndale.
Davis, Martha H.,	Auburndale.
Dodge, Rachel A.,	Grafton.
Eaves, Lucile,	Brookline.
Elder, Blanche,	Amherst.
Elder, Helen,	Amherst.
Farnam, Geraline E.,	Dalton.
Fisherdick, Florence M.,	Ware.
Flaherty, Jane S.,	Hadley.
Flaherty, Mary E.,	Hadley.
Flynn, Elizabeth C.,	Malden.
Frishmuth, Anna B.,	Boston.
Fuller, Edna,	Fredonia, N. Y.
Gavin, Madeline R.,	Roxbury.
Gee, Gretchen,	Fall River.
Gleason, Gertrude,	Newton Highlands.
Gleason, Mrs. Linnette,	Newton Highlands.
Goodnow, Edna M.,	Amherst.
Gould, Walter H.,	West Pelham.
Heatley, Elsie,	Wellesley.
Heatley, Margaret,	Wellesley.
Hitchcock, Caroline J.,	Amherst.
Hodsdon, Villa,	Cambridge.
Holmes, Miss R. M.,	Holyoke.
Hunt, Carrie A.,	Northampton.
Isquierdo, Bernardo,	New York City.
Jackman, Lucia L.,	Cambridge.
Kentfield, Annie L.,	Amherst.
Knox, Eloise,	Springfield.
Krall, Mabel,	Harrisburg, Pa.
Martin, Margaret,	Amherst.
May, Eleanor K.,	Jamaica Plain.
Maynard, Pearl A.,	West Newton.
Merrick, Marie,	Amherst.
Mills, Mrs. Frances Park,	Syracuse, N. Y.
Neal, Esther H.,	Williamstown.
Nelson, Lydia A.,	Jamestown, N. Y.
Newell, Mary W.,	Amherst.

Owen, Sarah,	Beaufort, S. C.
Page, Katherine,	Malden.
Palmer, Alice W.,	Shirley Center.
Pease, Elizabeth D. K.,	Brookline.
Plummer, Emma R.,	Newton.
Prince, Burton A.,	Westfield.
Rafter, Charlotte,	Dorchester Center.
Reed, Mrs. W. Maxwell,	Framingham.
Rice, Winifred,	Pittsfield.
Richardson, Sarah A.,	West Acton.
Robb, Genevieve,	Litchfield, Conn.
Ryan, Mabel F.,	Waltham.
Samper, Edward,	Amherst.
Samper, Santiago,	Amherst.
Sanger, Grace L.,	Boston.
Sargent, Jennette L.,	Boston.
Saunders, Bradford W.,	Cambridge.
Shipman, Julia,	Mattapan.
Smith, Mrs. Gertrude F.,	New Haven, Conn.
Smith, Claire E.,	Athol.
Swan, Annie L.,	Mattapan.
Tallman, Carlisle,	Amherst.
Teng, Shao-Ping,	China.
Turner, Wallace M.,	Providence, R. I.
Turner, Mrs. Wallace,	Providence, R. I.
Towne, Mary E.,	Brookline.
Walker, Mrs. G. S.,	Lexington.
Wright, Alfred E.,	Pittsfield.
Williams, Florence A.,	Pittsfield.

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PARTS I. AND II.,

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JANUARY, 1918.

ENDING THE THIRTY-FIFTH YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

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BEING PARTS III. AND IV. OF THE FIFTY-FIFTH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1918.

ENDING THE THIRTY-FIFTH YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

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THIRTIETH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART I.

REPORT OF THE DIRECTOR AND OTHER OFFICERS.

PART II.

DETAILED REPORT OF THE EXPERIMENT STATION.

A RECORD OF THE THIRTY-FIFTH YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

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Massachusetts Agricultural Experiment Station.

OFFICERS AND STAFF.

COMMITTEE.

Trustees.	Charles H. Preston, *Chairman*,	Hathorne.
	Wilfrid Wheeler,	Concord.
	Edmund Mortimer,	Grafton.
	Arthur G. Pollard,	Lowell.
	Harold L. Frost,	Arlington.

The President of the College, *ex officio*.
The Director of the Station, *ex officio*.

STATION STAFF.

Administration.

William P. Brooks,[1] Ph.D., *Director*.
Fred W. Morse,[2] M.Sc., *Acting Director*.
Joseph B. Lindsey, Ph.D., *Vice-Director*.
Fred C. Kenney, *Treasurer*.
Charles R. Green, B.Agr., *Librarian*.
Mrs. Lucia G. Church, *Clerk*.
Miss F. Ethel Felton, A.B., *Clerk*.

Agricultural Economics.

Alexander E. Cance, Ph.D., *In Charge of Department*.
Samuel H. DeVault, A.M., *Assistant*.

Agriculture.

William P. Brooks, Ph.D., *Agriculturist*.
Henry J. Franklin, Ph.D., *In Charge of Cranberry Investigations*.
Edwin F. Gaskill, B.Sc., *Assistant Agriculturist*.
Robert L. Coffin, *Assistant*.

Botany.

A. Vincent Osmun, M.Sc., *Botanist*.
George H. Chapman, Ph.D., *Research Physiologist*.
Paul J. Anderson, Ph.D., *Associate Plant Pathologist*.
Orton L. Clark, B.Sc., *Assistant Plant Physiologist*.
W. S. Krout, M.A., *Field Pathologist*.
Miss Mae F. Holden, B.Sc., *Curator*.
Miss Ellen L. Welch, A.B., *Stenographer*.

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[1] On leave from March 1.

[2] Beginning March 1.

Entomology.	Henry T. Fernald,[1] Ph.D., *Entomologist.*
	Burton N. Gates, Ph.D., *Apiarist.*
	Arthur I. Bourne, A.B., *Assistant Entomologist.*
	Stuart C. Vinal, M.Sc., *Assistant Entomologist.*
	Miss Bridie E. O'Donnell, *Clerk.*
Horticulture.	Frank A. Waugh, M.Sc., *Horticulturist.*
	Fred C. Sears, M.Sc., *Pomologist.*
	Jacob K. Shaw, Ph.D., *Research Pomologist.*
	Harold F. Tompson, B.Sc., *Market Gardener.*
	Miss Ethelyn Streeter, *Clerk.*
Meteorology.	John E. Ostrander, A.M., C.E., *Meteorologist.*
Microbiology.	Charles E. Marshall, Ph.D., *In Charge of Department.*
	Arao Itano, Ph.D.. *Assistant Professor of Microbiology.*
	George B. Ray, B.Sc., *Graduate Assistant.*
Plant and Animal Chemistry.	Joseph B. Lindsey, Ph.D., *Chemist.*
	Edward B. Holland, Ph.D., *Associate Chemist in Charge (Research Division).*
	Fred W. Morse, M.Sc., *Research Chemist.*
	Henri D. Haskins, B.Sc., *Chemist in Charge (Fertilizer Division).*
	Philip H. Smith, M.Sc., *Chemist in Charge (Feed and Dairy Division).*
	Lewell S. Walker, B.Sc., *Assistant Chemist.*
	Carleton P. Jones, M.Sc., *Assistant Chemist.*
	Carlos L. Beals, M.Sc., *Assistant Chemist.*
	James P. Buckley, Jr., *Assistant Chemist.*
	Windom A. Allen,[2] B.Sc., *Assistant Chemist.*
	John B. Smith,[2] B.Sc., *Assistant Chemist.*
	Robert S. Scull,[2] B.Sc., *Assistant Chemist.*
	Bernard L. Peables, B.Sc., *Assistant Chemist.*
	James T. Howard, *Inspector.*
	Harry L. Allen, *Assistant in Laboratory.*
	James R. Alcock, *Assistant in Animal Nutrition.*
	Miss Alice M. Howard, *Clerk.*
	Miss Rebecca L. Mellor, *Clerk.*
Poultry Husbandry.	John C. Graham, B.Sc., *In Charge of Department.*
	Hubert D. Goodale, Ph.D., *Research Biologist.*
	Miss Grace MacMullen, B.A., *Clerk.*
	Miss Elizabeth E. Mooney, *Clerk.*
Veterinary Science.	James B. Paige, B.Sc., D.V.S., *Veterinarian.*
	G. Edward Gage, Ph.D., *Associate Professor of Animal Pathology.*
	John B. Lentz,[2] V.M.D., *Assistant.*

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[1] On leave.

[2] On leave on account of military service.

REPORT OF THE DIRECTOR.

WM. P. BROOKS.

ADMINISTRATION.

STATION STAFF.

Most of the changes in the station staff during the past year have been in minor positions. Four men have entered the military service. To these, indefinite leaves of absence without salary have been granted, with the understanding that the positions given up will be open to them when they are honorably discharged from the service. These men were all doing satisfactory work, and their going creates vacancies which it will be difficult to fill. In very especial degree is this true of Dr. John B. Lentz, who volunteered for the veterinary service of the army, and who is now in France. For nearly two years Dr. Lentz had been in direct charge of the blood test work for the elimination of bacillary white diarrhœa, and in this position had shown a spirit, a devotion to duty and a degree of ability which rendered his services of very unusual value.

Dr. F. H. Hesselink van Suchtelen, who was engaged in an important line of investigation on the organic matter of soils, resigned his position in the department of microbiology in August to accept a chair in one of the leading universities of Holland, his native country. Dr. Arao Itano, who for several years has been an assistant in the department of microbiology, and in that position shown marked ability as an investigator, has been made assistant professor in the department, and will pursue a line of investigation closely related to that undertaken by Dr. van Suchtelen.

The staff has been strengthened during the year by the addition of two men for important lines of work not previously adequately cared for.

W. S. Krout, M.A., was made field pathologist in April, and will devote himself mainly to investigations of crop diseases as they occur upon the farms and in the gardens of the State. Mr. Krout, a graduate of Ohio State University, came to us from the New Jersey Agricultural Experiment Station where he had shown peculiar fitness for the line of work he is to follow in this State.

Stuart C. Vinal, M.Sc., who had for two years as graduate assistant done valuable investigational work in entomology, was made full assistant in the department in September, and is to give his entire time to study of insect problems.

Both Mr. Krout and Mr. Vinal will devote a considerable share of their attention to the problems affecting our market-garden interests.

Other changes in station staff require no special comment, though attention is called to the fact that resignations have in the majority of cases been due to the offer of higher salaries in other quarters. The salaries paid here, in subordinate positions especially, are low, and unless they can be raised it will be increasingly difficult to retain the services of good men.

Appointments and resignations of graduate assistants are not included as all such appointments are on a yearly basis, and while one or two reappointments, where conditions warrant and where acceptable, are the rule, these positions at best are temporary. The following is a complete statement of all other changes during the year.

Resignations.

Miss Marcella C. Curry, A.B., Clerk, Department of Poultry Husbandry.
Miss Eleanor Barker, Clerk, Department of Horticulture.
Miss Grace B. Nutting, Ph.B., Curator, Department of Botany.
F. H. Hesselink van Suchtelen, Ph.D., Associate Professor of Microbiology.
C. Theodore Buchholz, V.M.D., Assistant, Department of Veterinary Science.

Appointments.

Miss Grace B. Nutting, Ph.B., Curator, Department of Botany.
Miss Ellen L. Welch, A.B., Stenographer, Department of Botany.
Robert S. Scull, B.Sc., Assistant, Department of Plant and Animal Chemistry.
Miss Rachael G. Leslie, Clerk, Department of Poultry Husbandry.
W. S. Krout, M.A., Field Pathologist, Department of Botany.
Miss Mae F. Holden, B.Sc., Curator, Department of Botany.

Samuel H. DeVault, A.M., Assistant, Department of Agricultural Economics.

Arao Itano, Ph.D., Assistant Professor, Department of Microbiology.

Stuart C. Vinal, M.Sc., Assistant, Department of Entomology.

Miss Ethelyn Streeter, Clerk, Department of Horticulture.

C. Theodore Buchholz, V.M.D., Assistant, Department of Veterinary Science.

Bernard L. Peables, B.Sc., Assistant, Department of Plant and Animal Chemistry.

Leaves of Absence on Account of Military Service.

John B. Lentz, V.M.D., Assistant, Department of Veterinary Science, from August 31.

Robert S. Scull, B.Sc., Assistant, Department of Plant and Animal Chemistry, from September 11.

Windom A. Allen, B.Sc., Assistant, Department of Plant and Animal Chemistry, from September 16.

John B. Smith, B.Sc., Assistant, Department of Plant and Animal Chemistry, from October 5.

MAINTENANCE.

In accordance with the provision by the Legislature of 1912, the amount received from the State for general expenses was $5,000 greater than last year. The total revenues of the station were not quite $4,500 larger than last year, as there were shrinkages in receipts from sales of crops and in the fees obtained under the fertilizer law. The total revenues are shown in the following table: —

Total Revenue for the Fiscal Year, Dec. 1, 1916, to Nov. 30, 1917.

State appropriation,	$35,000 00
Federal appropriations: —	
Hatch fund,	15,000 00
Adams fund,	15,000 00
Agricultural department, sales and labor,	4,810 22
Chemical department, sales, cow testing and analytical work,	11,939 54
Miscellaneous receipts from various departments,	50 49
Blood tests,	560 31
Fertilizer law,	9,040 00
Feed law,	6,000 00
Cranberry substation,	3,172 02
Graves' orchard,	133 48
Tillson farm,	1,120 55
Total,	$101,826 61

The cost of executing the provisions of the fertilizer and feed laws was $16,132.24, which left for the general work of the station $85,694.37. From this amount there was required in round numbers $12,000 for the cost of cow testing, standardizing dairy apparatus, making water analyses and performing interdepartment services, thus leaving for investigations approximately $73,700, which was about $6,000 more than in the previous year. The treasurer's report will be found on pages 17*a* and 18*a*.

PUBLICATION.

The list of publications for the year includes nine bulletins aggregating 335 pages in the regular series, and two bulletins in the control series aggregating 94 pages. The arrangement regarding circulars, which was mentioned in the last report, resulted in all the circulars for the year being cared for by the extension service.

Annual Report.

Twenty-ninth annual report: —
Part I. Report of the Director and Other Officers; 92 pages.
Part II. Detailed Report of the Experiment Station; 307 pages (being Bulletins Nos. 168–172).
Combined Contents and Index, Parts I. and II.; 20 pages.

Bulletins.

No. 173. The Cost of Distributing Milk in Six Cities and Towns in Massachusetts, by Alexander E. Cance and Richard Hay Ferguson; 54 pages.
No. 174. The Composition, Digestibility and Feeding Value of Pumpkins, by J. B. Lindsey; 18 pages.
No. 175. Mosaic Disease of Tobacco, by G. H. Chapman; 46 pages.
No. 176. The Cause of the Injurious Effect of Sulfate of Ammonia when used as a Fertilizer, by R. W. Ruprecht and F. W. Morse; 16 pages.
No. 177. Potato Plant Lice and their Control, by W. S. Regan; 12 pages.
No. 178. The European Corn Borer, *Pyrausta nubilalis* Hübner, a recently established pest in Massachusetts, by S. C. Vinal; 6 pages.
No. 179. The Greenhouse Red Spider attacking Cucumbers and Methods for its Control, by S. C. Vinal; 30 pages.

No. 180. Report of the Cranberry Substation for 1916, by H. J. Franklin, and Observations on the Spoilage of Cranberries due to Lack of Proper Ventilation, by C. L. Shear and Neil E. Stevens, Pathologists, and B. A. Rudolph, Scientific Assistant, Fruit-Disease Investigations, Bureau of Plant Industry, United States Department of Agriculture; 58 pages.

No. 181. Digestion Experiments with Sheep, by J. B. Lindsey, C. L. Beals and P. H. Smith; 95 pages.

Bulletins, Control Series.

No. 7. Inspection of Commercial Feedstuffs, by P. H. Smith; 30 pages.

No. 8. Inspection of Commercial Fertilizers, by H. D. Haskins; 64 pages.

Meteorological Reports.

Twelve numbers, 4 pages each.

MAILING LISTS.

At considerable expense for time and labor our mailing lists have been maintained in as live a condition as possible, and at present are arranged by lists, as tabulated below.

Residents of Massachusetts (general),	11,603
Residents of other States (general),	1,549
Residents of other States (technical and general),	1,068
Exchange list,	249
Massachusetts libraries,	191
Out-of-State libraries,	251
Massachusetts agricultural schools and departments,	55
Massachusetts county farm bureaus,	12
Massachusetts Agricultural College and Experiment Station staffs,	101
Beekeepers,	4,356
Newspapers,	436
Cranberry growers,	1,398
Meteorological,	385
Feed list,	250
Fertilizer list,	86
Massachusetts milk inspectors,	158
Massachusetts milk dealers,	135
Miscellaneous special lists,	254
United States Department of Agriculture, official list,	3,602[1]
Total,	26,139[2]

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[1] Publications are not as a rule sent to all on this list, but only to directors, libraries and specialists likely to be interested.

[2] Of this total, 314 foreign addresses are included under different lists.

ESSENTIALS FOR NEEDED DEVELOPMENT.

In the last annual report there was presented a statement covering the more essential requirements for the normal development of the station work for the next five years, which was prepared at the suggestion of the Special Commission on Agricultural Education at the Massachusetts Agricultural College and the Development of the Agricultural Resources of the Commonwealth. Some progress has been made during the year in meeting these needs.

Arrangements have been completed for the purchase of the Tillson farm, though it will still be necessary for the next three years for the station to pay the sum agreed upon for the annual rent, which, however, under the plan adopted, will be directly applied toward the payment of the purchase price which will then be met in full.

Two lots of land are still needed, as described last year, viz., the Tuxbury land which is leased for orchard experiments, and a suitable poultry farm. It seems necessary to present again these two important projects for development, that they may be kept in mind by the followers of the station's work.

The Tuxbury land includes a total area of about 30 acres, of which 18 acres are now leased by the station, and the remainder consists of sprout land. It is estimated to cost now about $12,000, but the price is sure to increase. A large part of the leased land is planted to apple orchard for the experiment with stock and cion relationships. The trees will barely have reached the period of most profitable production at the expiration of the lease. Ultimate ownership is highly desirable, and it seems the part of wisdom to acquire the property at as early a date as possible.

The area desired for a poultry farm is about 60 acres, and it is estimated that such a farm will cost $8,000. We have for some years been compelled to lease land on which to raise young stock, and this policy is quite unsatisfactory.

Building needs have not been met and remain as described last year, viz., house, barn and sheds for the Tillson farm, buildings for the poultry department, an addition to the building at the cranberry substation, and greenhouses for experimental work at the market-garden field station.

Important additions to the station staff made during the year have been mentioned, but men are needed to take up additional lines of work. There is decided need for experimental work in rural engineering, in floriculture and in forestry. Provision for this work should be made at as early a date as possible. Particularly urgent are investigations in rural engineering and in forestry. There will be required, also, moderate increases in salaries for a considerable number of those now on the station staff. It is estimated that to provide for the new men and the needed increases will require within five years an addition to the amount now available for salaries of $40,000.

Increases for annual support of the station work and equipment were quite carefully estimated in last year's report and amounted to $30,000.

WORK OF THE YEAR.

The serious situation as affecting the food supply due to the war suggested the desirability of a careful consideration of the question as to whether lines of investigation in progress should not be modified and new ones undertaken. With a view to getting suggestions from individuals who it was believed are as well qualified to make such suggestions as any in the State, a meeting of the advisory council, composed of representatives of the various agricultural interests, was called in June. The investigations in progress were quite comprehensively, though of necessity briefly, described, after which opportunity was given for discussion and suggestions. If we may judge from the fact that no important new investigations were suggested, it would appear that the scope of our work as affecting food production and distribution was regarded by the members of the council present as fairly satisfactorily covering the ground.

During the past year we have undertaken a few new lines of investigation. In connection with the cranberry substation in Wareham we have established in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture a plantation of swamp blueberries, with a view to investigating the possibilities of blueberry culture.

The very high price of the cereal grains has indicated the probability that under existing conditions Massachusetts may profitably engage in the production of these grains on a much more extensive scale than in recent years. A considerable area on the Tillson farm, and a smaller area on the home grounds of the station, therefore, are being used for the trial of nine different varieties of winter wheat and a new variety of winter rye and of winter barley.

The chemical department, in co-operation with several other experiment stations, under the general suggestive leadership of Dr. H. P. Armsby, is beginning a series of experiments to determine the minimum protein requirements of growing animals. The solution of this problem should have an important bearing upon the economy of meat production.

A number of forage crops new in the agriculture of the State and a considerable number of feeds also relatively unknown have been under investigation as regards their value and adaptability to local conditions.

Important investigations which should throw light upon the most satisfactory methods of feeding horses have been begun during the year. In these investigations the digestibility by horses of the important feeding stuffs, and their available energy in the animal economy, will be determined.

Experiments having indicated the superior value of the types of rust-resistant asparagus produced in the breeding work at Concord, a considerable area has been set with plants of the best variety for the purpose of producing seed in such quantities that the demand of growers of the crop for the new variety may be met.

As the probable value of soy beans in the existing and prospective food emergency has been quite generally recognized, it was felt that there would be a large demand for seed, and a considerable area on the Tillson farm, as well as smaller areas on such of the station plots as could be used for the purpose, were planted to one of the best varieties.

Fairly satisfactory progress has been made in the investigation into the causes of tobacco sickness, although a hail storm of exceptional severity did much damage to a portion of the plots.

The control work of the station has received the usual careful attention. The high price and scarcity of fertilizers seems to have suggested unusual activity on the part of those engaged in the production and sale of relatively worthless articles. An energetic campaign, believed to have been quite successful, was carried on with a view to preventing or limiting the amount of such sales.

The reports from the different departments of station work, summarizing their activities for the year, will be found following the treasurer's report, on pages 17 *a* and 18 *a*.

STATEMENTS OF EXPENDITURES FOR SPECIAL LINES OF WORK.

FERTILIZER LAW ACCOUNT, DEC. 1, 1916, TO NOV. 30, 1917.

Balance Dec. 1, 1916,		$859 81	
Total fees,		9,040 00	
			$9,899 81

Expenditures.

Chemicals,		$269 52	
Apparatus,		275 08	
Salaries: —			
Chemical and administrative,	$5,395 32		
Clerical,	520 00		
		5,915 32	
Collection expenses: —			
Inspector's salary,	$722 83		
Travel,	773 49		
Freight and express,	25 17		
		1,521 49	
Laboratory assistance,		164 97	
Official travel,		64 32	
Gas,		133 01	
Office supplies,		23 79	
Miscellaneous supplies,		58 30	
Repairs,		12 89	

Publication and mailing: —			
Control Bulletin No. 6,	$870 20		
Fertilizer law circulars,	8 50		
Mailing,	31 05		
		$909 75	
Laundry,		12 70	
Legal services,		48 94	
Fertilizer experiment: —			
Fertilizers,		2 00	
Total,			$9,412 08
Balance Dec. 1, 1917,			$487 73

Feed Law Account, Dec. 1, 1916, to Nov. 30, 1917.

Balance on hand Dec. 1, 1916,	$2,048 07	
State appropriation,	6,000 00	
		$8,048 07

Expenditures.

Salaries: —		
Chemical,	$2,861 30	
Clerical,	420 00	
		$3,281 30
Collection expenses: —		
Inspector's salary,	$360 00	
Inspector's travel,	337 55	
Express on samples,	6 57	
		704 12
Laboratory assistance,		89 63
Gas,		35 13
Apparatus,		20 82
Chemicals,		222 52
Office supplies,		2 39
Miscellaneous travel,		59 07
Telephone,		15 53
Repairs,		11 91
Miscellaneous supplies,		70 75
Laundry,		3 62
Legal expenses: —		
Lawyer's fees,	$54 00	
Travel,	27 35	
		81 35

Feeding experiment with horses: —			
Salary,	$300 00		
Repairs to building,	878 44		
Travel,	104 30		
Apparatus,	39 35		
		$1,322 09	
Publication: —			
Control Bulletin No. 5,	$781 20		
Addressing envelopes and mailing,	18 33		
		799 53	
Total,			$6,719 76
Balance Dec. 1, 1917,			$1,328 31

Graves' Orchard, Dec. 1, 1916, to Nov. 30, 1917.

Apportionment,		$700 00

Expenditures.

Hauling and spreading manure, mixing fertilizers and burning brush,	$21 05	
Pruning,	54 15	
Spraying and spray materials,	50 67	
Harrowing,	30 90	
Thinning,	21 40	
Harvesting,	134 30	
Barrels,	89 10	
Freight on barrels,	6 60	
Measuring trees,	1 13	
Rent,	75 00	
Travel,	59 76	
Mowing (1916),	2 00	
Care of bees,	2 00	
Total,		548 06
Balance Dec. 1, 1917,		$151 94

Receipts.

Barrels (1916 bill),	$29 70	
Apples (1917 crop),[1]	103 78	
Total,		$133 48

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[1] Balance of crop valued at $1,000.

TILLSON FARM, DEC. 1, 1916, TO NOV. 30, 1917.

	Expenditures.	Receipts.
Apportionment,	-	$1,400 00
Rent,	$385 00	37 00
Taxes,	54 54	-
Repairs,	12 50	-
Travel,	23 24	-
Apple orchard: —		
1916 crop,	-	13 75
1917 crop,	88 87	109 50
Corn,	123 62	-[1]
Grasslands: —		
1916 crop,	205 57	466 48
1917 crop,	302 97	111 99[2]
Pasture,	57 77	150 00
Soy beans,	289 17	-[1]
Squash,	18 70	5 23[2]
Tomatoes: —		
1916 crop (seed),	30 00	180 40
1917 crop,	36 00	46 20
Wheat,	44 77	-[3]
Totals,	$1,672 72	$2,520 55

[1] Crop not yet sold.

[2] Larger part of crop unsold.

[3] Winter wheat planted in the fall of 1917.

CRANBERRY SUBSTATION, DEC. 1, 1916, TO NOV. 30, 1917.

Receipts.

Cranberries, crop of 1916,	$1,734 66	
Cranberries, crop of 1917,	1,247 85	
United States Weather Bureau,	125 83	
Unneeded apparatus returned and sold,	63 68	
		$3,172 02
Bills receivable on Dec. 1, 1917 (estimated),		545 00
Cranberries on hand Dec. 1, 1917 (estimated),		483 00
Total received and receivable,		$4,200 02

Expenditures — Bog Account.

Maintenance: —		
Tools and similar equipment bought or repaired,	$11 58	
Oil for engine, etc. (gasoline, kerosene, lubricating),	180 25	
Pumping labor,	31 88	
Mowing of upland,	57 61	
Weeding,	55 93	
Lumber and hardware,	3 91	
Raking vines after picking,	48 15	
Resanding the bog,	226 43	
Miscellaneous labor,	59 17	
Sundries,	4 40	
		$679 31
Harvesting: —		
Picking cranberries,	$456 68	
Separating cranberries,	38 37	
Screening cranberries,	181 69	
Packing cranberries and tending screeners,	57 00	
Carting cranberries,	30 39	
Coopering and mending boxes,	21 55	
Packing materials (barrels, crates, etc.),	214 76	
Contingent,	2 50	
		1,002 94
Improvements: —		
Building roads,		9 30
		$1,691 55

Expenditures — Experimental Account.

Experimental labor,		$1,031 98
Supplies and apparatus,		204 96
Office machines and appliances,		22 69
Chemicals (including fertilizers and insecticides),		27 41
Lumber,		60 25
Traveling expenses,		86 13
Stenographer,		116 32
Printing,		25 00
Rental of dry bog for season of 1916,		60 00
Blueberry plantation: —		
Sewer pipe,	$19 78	
Constructing flume and pipe line for irrigating the plantation,	10 05	
Transplanting selected wild bushes,	20 81	
Plowing and harrowing,	20 90	
Cultivating and hoeing,	5 35	
Sundries,	4 48	
		81 37

Contingent: —		
Freight and express,	$20 75	
Telephone,	19 64	
Fuel,	31 50	
Furnishings,	44 00	
Books, stationery and postage,	4 94	
		$120 83
Total,		$1,836 94

Summary of Disbursements.

Disbursements on bog account,	$1,691 55	
Disbursements on experimental account,	1,836 94	
Total disbursements,		$3,528 49

Tobacco Investigations, 1917.

Expenditures (exclusive of Salaries).[1]

Fertilizers,[2]	$408 46	
Travel,	215 14	
Land rental,[3]	110 00	
Extra labor,	6 75	
Cartage,	7 75	
Photographic work,	8 85	
Stakes,	2 16	
Total cost,		$759 11

Materials on Hand.

1,000 pounds high-grade sulfate of potash at $240,	$120 00	
Miscellaneous fertilizers,	8 40	
		128 40
Net cost of investigations,		$630 71

Owing to illness Director Brooks was given a leave of absence from March 1, 1918. The material for the annual report had been practically all written but not assembled and arranged before this date.

FRED W. MORSE,
Acting Director.

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[1] Approximate amount for salaries, $1,583.35.

[2] One item of $4.31 was not paid out of 1917 apportionment.

[3] The rate of rental was to be $40 per acre for open plots and $90 per acre for shade plots, and this item would be $170; but for 1917 one grower donated the use of 1 acre of land and another the use of one-half acre, reducing rental by $60.

REPORT OF THE TREASURER.

ANNUAL REPORT

Of Fred C. Kenney, Treasurer of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College, for the Year ending June 30, 1917.

United States Appropriations, 1916–17.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1917, under acts of Congress approved March 2, 1887, and March 16, 1906,	$15,000 00	$15,000 00
Cr.		
By salaries, ...	$15,000 00	$15,000 00

State Appropriation, 1916–17.

Cash balance brought forward from last fiscal year,	$16,359 90
Cash received from State Treasurer,	38,500 00
fees,	9,641 81
sales,	10,903 08
miscellaneous,	12,418 39
	$87,823 18
Cash paid for salaries,	$25,558 43
labor,	22,912 62
publications,	2,440 80
postage and stationery,	1,971 85
freight and express,	354 83
heat, light, water and power,	482 03
chemicals and laboratory supplies,	2,435 29
seeds, plants and sundry supplies,	2,643 97
fertilizer,	1,056 51
feeding stuffs,	1,670 01
library,	685 23
tools, machinery and appliances,	787 95
furniture and fixtures,	641 61
scientific apparatus and specimens,	546 74
live stock,	446 20
traveling expenses,	4,037 79
contingent expenses,	25 00
buildings and land,	3,225 32
balance,	15,901 00
Total,	$87,823 18

DEPARTMENT OF AGRICULTURAL ECONOMICS.

ALEXANDER E. CANCE.

The work of the department this year has been prosecuted along two lines, — first, the regular research projects, and second, war emergency projects requiring immediate attention and less thorough investigation.

Regular Projects.

The investigation into methods and cost of tobacco marketing has been continued by Mr. S. H. DeVault, research assistant, and is being rounded into shape. As an incident of this investigation he has been asked by groups of farmers to present plans for some marketing organization of farmers, by means of which the production and market distribution of the tobacco of the Connecticut Valley may be conducted more economically.

Emergency Projects.

(*a*) *Census of Agricultural Production.* — The department holds that any intelligent program of farm production must be based on a knowledge of the agricultural resources, — land and equipment, — labor and previous farm practices. There are no such facts available by towns later than 1905. For this reason the department initiated and directed such a census in Hampshire, Franklin, Berkshire and Worcester counties, beginning early in April, 1917. The data were tabulated at the college, and copies sent to the county farm bureaus and the public safety committees of the counties and of each town.

(*b*) *Consumption Survey.* — A survey of the food and feed consumption of every town and city in Hampshire County of 5,000 or over population, and 15 towns and cities in Hampden County, was undertaken by Mr. DeVault and assistants last spring. The purpose was to ascertain the food and feed needs of the people as determined by the purchases and sales of retailers, wholesalers, fruit stands, restaurants and bakeries, hotels, boarding houses and transportation companies, to ascertain how many of these products are purchased locally, how many are shipped in and what is the amount ordinarily stored. The survey included 403 retail stores, 37 hotels and boarding houses, 42 fruit stands, 24 restaurants and lunch counters, and 21 bakeries, serving 144,000 people. In general, it was found that these establishments purchase a comparatively small percentage of local products. For example, only 8 per cent. of the beans, 22 per cent. of the potatoes, 58 per cent. of the apples, 33 per cent. of the eggs, 12 per cent. of the butter, 63 per cent. of the milk, 32 per cent. of the cabbage and 4½ per cent. of the meats handled by these establishments are locally produced. Using the detailed data of this investigation it is possible to plan to meet the needs of this population in a manner somewhat more economical and more efficient than at present, and preferably by the production and use of local products.

The data have been partially tabulated and interpreted, and copies have been sent back to the local authorities for use in their food campaign. The department hopes to publish the results of the survey this year. Only lack of funds has prevented a further and more complete study.

(c) *Market Milk Investigation.* — In August, 1917, the department of agricultural economics was asked by the Boston Chamber of Commerce and the Attorney-General of Massachusetts to undertake an investigation of the distributing costs of twenty or more milk dealers in the city of Boston, to the end that equitable prices for producing and marketing milk might be established. Mr. William L. Machmer and Mr. Otto F. Wilkinson of the college staff were assigned the field work about September 1, and in six weeks were ready to make a preliminary report on twenty dealers handling approximately 12,600,000 quarts of milk and cream annually, a commendable record of efficiency and economy. A similar investigation of another group of dealers conducted at the same time cost the State five to ten times more. These data were used by the Federal District Milk Commission in making their award. The department hopes to publish the data as a supplement to Bulletin No. 173.

DEPARTMENT OF AGRICULTURE.

E. F. GASKILL.

The work of the agricultural department has been continued during the past year along the same general lines followed in previous years. A large share of the experimental work of this department has to do with the study of different phases of the question of soil fertility. This necessitates the care and management of a large number of field plots. This year the work has involved the use of 230 field plots, 13 orchard plots, 23 pasture plots, 143 closed plots and 432 pots in our vegetation experiments.

No experimental work has been started on the newly acquired Tillson farm, as the buildings there are not suitable for storage. The crops grown on this farm this year were "war emergency crops" and hay. Four varieties of winter wheat were sown this fall to determine whether any of these varieties are suitable for this section.

The supervision of the field work on the Tuxbury land, on which are set about 1,100 trees to be used for experimental work, also comes under this department.

The work of the agricultural department as set forth from year to year in the annual reports may be considered a report of progress. No attempt is made to report in full all the activities of the department, but to mention only a few of the more important lines of investigation. The same policy will be followed this year.

FIELD A, OR THE NITROGEN EXPERIMENT.

The experiment has been continued for twenty-eight years, and has had for its object the determination of the relative value as sources of nitrogen of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood; also the effect on the no-nitrogen plots of turning under the roots and stubble of a leguminous crop. The field was divided in 1909, and half of each plot received an application of lime at the rate of 2½ tons per acre; again, in 1913, the same half of each plot received an application of lime at the rate of 2 tons per acre. The crops since liming have been: 1909, clover; 1910, clover; 1911, corn followed by clover; 1912, corn followed by clover; 1913, Japanese millet; 1914, oats, grass and clover; 1915, grass and clover; 1916, Japanese millet.

This year the crop was Green Mountain potatoes. The yields on the different plots are shown in the following table: —

Potatoes.

Plot.	FERTILIZER.	Fertilizer per Acre (Pounds).	YIELDS PER ACRE (BUSHELS).					
			LIMED.			UNLIMED.		
			Large.	Small.	Total.	Large.	Small.	Total.
0	Stable manure,[1]	8,000	345.00	27.67	372.67	227.33	21.67	249.00
1	Nitrate of soda, Muriate of potash, Dissolved boneblack,	290 150 500	333.33	35.33	368.67	242.67	21.00	263.67
2	Nitrate of soda, Sulfate of potash-magnesia, Dissolved boneblack,	290 300 500	379.67	34.33	414.00	299.00	24.67	323.67
3	Dried blood, Muriate of potash, Dissolved boneblack,	525 150 500	328.67	28.00	356.67	285.67	16.67	302.33
4	Sulfate of potash-magnesia, Dissolved boneblack,	300 500	343.17	16.67	359.83	256.33	14.00	270.33
5	Sulfate of ammonia, Sulfate of potash-magnesia, Dissolved boneblack,	225 300 500	310.67	19.00	329.67	209.33	15.83	225.17
6	Sulfate of ammonia, Muriate of potash, Dissolved boneblack,	225 150 500	284.25	24.00	308.25	227.67	20.50	248.17
7	Muriate of potash, Dissolved boneblack,	150 500	300.42	24.67	325.08	139.50	22.00	161.50
8	Sulfate of ammonia, Muriate of potash, Dissolved boneblack,	225 150 500	308.50	21.33	329.83	200.17	18.25	218.42
9	Muriate of potash, Dissolved boneblack,	150 500	292.17	24.08	316.25	152.50	19.17	171.67
10	Dried blood, Sulfate of potash-magnesia, Dissolved boneblack,	525 300 500	318.83	31.67	349.50	271.67	17.25	288.92

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[1] To equalize the nitrogen, phosphoric acid and potash, this plot received in addition to the manure: —

Nitrate of soda,	110 pounds per acre.
Sulfate of potash-magnesia,	150 pounds per acre.
Dissolved boneblack,	380 pounds per acre.

The tubers were examined closely for scab at the time of digging. On the limed area of all plots there were some scabby tubers, but not enough to seriously affect the yield of merchantable potatoes except on plots 0 and 10. On plot 0 about 75 per cent. of the potatoes were scabby, and on plot 10 about 50 per cent. were scabby. On the unlimed area of the different plots there was no scab at all except on plots 0 and 1. On these about 10 per cent. of the tubers were scabby. The tubers on the unlimed areas were smaller, smoother and of better quality than those on the limed areas, but the yield was greater in each case on the limed areas.

Field B, Comparison of Muriate and High-grade Sulfate of Potash.

In this experiment, which has continued for twenty-five years, a great variety of crops has been grown. The results obtained under our climatic and soil conditions show that muriate has proved the better source of potash for the following: asparagus (eleven years); currants (four years); mangels (two years); sugar beets (one year); corn, ensilage (one year); corn stover (seven years); sweet corn stover (one year); squashes (three years); carrots (two years); onions (two years); celery (one year); oat hay (one year); vetch and oats (two years); and alfalfa (one year).

The high-grade sulfate has proved the better source for the following: asparagus (one year); blackberries (eleven years); raspberries (eleven years); strawberries (eleven years); rhubarb (twelve years); potatoes (twelve years); corn, grain (eight years); corn stover (one year); sweet corn, ears (one year); cabbages (ten years); soy beans (five years); alfalfa (four years); crimson clover (one year); medium red clover (one year); alsike clover (one year); common red and alsike clover (one year); and mammoth red clover (one year).

The crops grown this year were: alfalfa, blackberries, currants, gooseberries, mangels, rhubarb, raspberries and soy beans. The results obtained are in accordance with those obtained in previous years, with the exception of raspberries. This year the better yield of raspberries was obtained on the muriate plot.

FIELD C, CHEMICAL FERTILIZERS AND MANURE FOR MARKET-GARDEN CROPS.

In this experiment, which has continued for twenty-seven years, we have grown practically all of the market-garden crops common in this State. The object of the experiment has been to determine the effect of the addition to manure of chemical fertilizers for these crops; also to compare three materials as sources of nitrogen and two as sources of potash. The results obtained this year are shown in the following table: —

Yields per Acre.

Plot.	Fertilizer.[1]	Fertilizer per Acre (Pounds).	Asparagus (Pounds).	Tomatoes (Pounds).	Beets (Pounds).				Onions (Bushels).	
					Limed.		Unlimed.		Limed.	Unlimed.
					Roots.	Tops.	Roots.	Tops.		
0	No fertilizer,	-	6,724	41,698	67,550	14,362	72,340	16,224	339.3	306.5
1	Sulfate of ammonia, Muriate of potash, Dissolved boneblack,	304 100 320	6,090	60,835	96,460	30,210	70,417	27,500	256.1	116.9
2	Nitrate of soda, Muriate of potash, Dissolved boneblack,	376 100 320	7,083	51,723	50,000	11,042	54,792	13,542	251.2	387.3
3	Dried blood, Muriate of potash, Dissolved boneblack,	440 100 320	6,794	57,276	86,250	20,417	70,625	20,417	342.6	330.6
4	Sulfate of ammonia, Sulfate of potash, Dissolved boneblack,	304 100 320	6,581	60,774	78,333	22,292	40,833	18,750	255.5	146.6
5	Nitrate of soda, Sulfate of potash, Dissolved boneblack,	376 100 320	8,368	61,534	60,625	19,167	59,592	18,542	304.4	278.4
6	Dried blood, Sulfate of potash, Dissolved boneblack,	440 100 320	7,330	55,303	70,625	21,875	78,125	21,875	308.6	298.9

[1] All plots received an application of manure at the rate of 60,000 pounds per acre.

FIELD G, COMPARISON OF POTASH SALTS.

This is the twentieth year of the experiment which has had for its object the comparison of seven different materials that may be used as sources of potash. There are 40 plots in all, including 5 check or no-potash plots and 5 plots on which each of the different potash materials are used. The rate of application of actual potash has been in previous years 135 pounds of potassium oxide per acre; this year the application was reduced to 75 pounds. The different materials furnishing potash are: kainit, high-grade sulfate of potash, low-grade sulfate of potash, muriate of potash, nitrate of potash, carbonate of potash and treater dust. All plots receive annually the following mixture supplying nitrogen and phosphoric acid: —

	Pounds per Acre.
Nitrate of soda,[1]	250
Tankage,	270
Acid phosphate,	360

In 1915 all plots received the usual application of nitrogen and phosphoric acid, but no potash. This year all plots received the usual application of nitrogen and phosphoric acid, and all except the fourth series (plots 25–32) received the application of potash. On this set of plots the potash was omitted.

The crop this year was Early Canada Flint corn, which, owing to the late season, was not planted until June 22. The yield per acre of the different plots is shown in the following table: —

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[1] Plots 6, 14, 22, 30 and 38, which receive nitrate of potash, receive only enough nitrate of soda to make up the deficiency in nitrate, — this year, 108 pounds per acre.

Corn (*Yields per Acre*).

POTASH.	Plot.	Corn (Bushels).	Stover (Pounds).	Plot.	Corn (Bushels).	Stover (Pounds).	Plot.	Corn (Bushels).	Stover (Pounds).	Plot.	Corn (Bushels).	Stover (Pounds).	Plot.	Corn (Bushels).	Stover (Pounds).
No potash,	1	57.1	3,400	9	55.4	3,800	17	44.9	3,400	25[1]	21.4	2,000	33	32.5	2,800
Kainit,	2	59.7	4,600	10	54.8	5,000	18	38.6	3,800	26[1]	40.0	3,400	34	56.0	4,800
High-grade sulfate,	3	61.1	5,200	11	56.0	4,600	19	32.0	3,000	27[1]	46.9	3,800	35	53.7	5,000
Low-grade sulfate,	4	61.7	4,200	12	53.7	4,200	20	32.3	3,400	28[1]	43.7	3,600	36	61.1	5,600
Muriate,	5	59.4	5,200	13	53.7	4,200	21	34.3	3,400	29[1]	51.2	4,400	37	65.4	6,800
Nitrate,	6	62.0	4,600	14	48.6	3,600	22	36.6	3,600	30[1]	57.2	4,800	38	55.4	5,200
Carbonate,	7	63.4	4,800	15	52.8	4,800	23	38.9	3,600	31[1]	54.3	3,800	39	57.7	5,000
Treater dust,	8	60.0	3,800	16	50.0	5,000	24	43.4	3,400	32[1]	39.5	3,200	40	45.7	4,800

[1] No potash applied this year.

Comparison of Different Phosphates.

This experiment was begun in 1897, and has for its object a comparison of ten different materials that may be used as sources of phosphoric acid. The data for the first eighteen years of the experiment were published in Experiment Station Bulletin No. 162.

The materials furnishing phosphoric acid are applied in sufficient quantity to supply 96 pounds per acre of actual phosphoric acid. Each plot receives an annual application of the following mixture furnishing nitrogen and potash: —

	Pounds per Acre.
High-grade sulfate of potash,	160
Nitrate of soda,	364
Sulfate of ammonia,	100
Hoof meal,[1]	102

The crop this year was Medium Green soy beans. Owing to an early frost the crop did not yield as well as usual. The following table gives the results obtained: —

Soy Beans (Yields per Acre).

Plot.	Phosphate.	Beans (Bushels).	Straw (Pounds).
1	No phosphate,	16.66	4,234
2	Arkansas rock phosphate,	16.86	4,222
3	South Carolina rock,	13.00	3,526
4	Florida soft rock,	15.34	3,750
5	Slag,	18.48	6,848
6	Tennessee rock,	15.17	3,640
7	No phosphate,	17.86	5,044
8	Dissolved boneblack,	18.97	5,060
9	Raw bone,	18.55	5,444
10	Dissolved bone meal,	18.93	5,062
11	Steamed bone,	17.69	4,974
12	Acid phosphate,	19.00	4,498
13	No phosphate,	18.58	3,322

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[1] Plots 9, 10 and 11, which receive phosphoric acid in some form of bone, receive only enough hoof meal to equalize the organic nitrogen.

NORTH CORN ACRE.

For twenty-seven years there have been under comparison on this field two fertilizer mixtures. In one, the percentage of potash is high and that of phosphoric acid low; in the other (which represents about the average analysis of the commercial corn fertilizers offered on our markets) the percentage of phosphoric acid is high and that of potash low. For twenty-one years the rotation on this field has been two years grass and two years corn. The seed (a mixture of timothy, red top and clover) has usually been sown in the standing corn the latter part of July. The soil has not had the benefit of a green manure crop nor an application of manure during the twenty-six years of the experiment. The turf and corn stubble which have been plowed under have been the only source of humus.

This year potash was omitted from the mixture containing the lower amount and cut down in the mixture containing the larger amount, so that plots 1 and 3 this year received no potash, and plots 2 and 4 received potash at the rate of 160 pounds of muriate per acre instead of 250 pounds per acre as in previous years.

The crop this year was mixed grass and clover. The results obtained are in accordance with those of previous years, viz., the combination containing the larger per cent. of potash gives the larger yield of hay.

NORTH SOIL TEST.

This is the twenty-eighth year of this experiment, which has for its object a study of the effect of the continued use of fertilizers containing single plant-food elements and different combinations of plant-food elements for different crops; also the effect of lime added to each fertilizer under comparison.

The west half of each plot received an application of hydrated lime at the rate of 1 ton per acre in 1899 and again in 1904, and at the rate of one-half ton per acre in 1907. In 1916, 2 tons per acre of ground limestone were applied.

The crop this year was cabbages. The following table gives the yields per acre and the fertilizer schedule: —

Cabbages.

Plot.	Fertilizer.	Fertilizer per Acre (Pounds).	Yields per Acre (Pounds).					
			Limed.			Unlimed.		
			Good.	Poor.	Total.	Good.	Poor.	Total.
1	No fertilizer, . . .	–	10,120	10,160	20,280	240	1,760	2,000
2	Nitrate of soda, . .	160	13,640	9,600	23,240	880	2,200	3,080
3	Dissolved boneblack, .	320	2,980	6,240	9,220	2,560	7,240	9,800
4	No fertilizer, . . .	–	7,240	9,240	16,480	100	920	1,020
5	Muriate of potash, . .	160	15,360	7,320	22,680	180	1,400	1,580
6	Nitrate of soda, . . Dissolved boneblack, .	160 320	21,560	5,880	27,440	13,560	9,600	23,160
7	Nitrate of soda, . . Muriate of potash, . .	160 160	20,400	7,600	28,000	160	840	1,000
8	No fertilizer, . . .	–	9,320	10,560	19,880	160	1,240	1,400
9	Dissolved boneblack, . Muriate of potash, . .	320 160	25,000	7,720	28,720	6,320	7,560	13,880
10	Nitrate of soda, . . Dissolved boneblack, . Muriate of potash, . .	160 320 160	42,480	2,920	45,400	26,040	7,320	33,360
11	Plaster, ...	800	3,980	9,320	13,300	720	6,240	6,960
12	No fertilizer, . . .	–	7,520	9,480	17,000	–	1,040	1,040
13	Nitrate of soda, . . Dissolved boneblack, . Muriate of potash, . . Dried blood, . . .	160 320 160 160	47,720	2,320	50,040	18,200	5,880	24,080

These results are in accordance with those of earlier years when a crucifer has been the crop. The largest yields are obtained where the mixtures containing phosphoric acid are used, and on all plots except where the phosphoric acid is used alone an application of lime increases the yield.

SOUTH SOIL TEST.

This experiment was begun in 1889, and has for its object a study of the effect of the continued use of fertilizers containing single plant-food elements and different combinations of plant-food elements for different crops. The whole field received an application of lime at the rate of 1 ton per acre in 1899 and again in 1904, at the rate of one-half ton per acre in 1907, and of ground limestone at the rate of 2 tons per acre in 1916.

The following table shows the yields per acre of corn and stover obtained on the different plots in 1917 and 1915. The increase in yield in 1917 over that in 1915 may be due to the fact that the variety grown in 1917 was Early Canada, and that grown in 1915 was Longfellow; or it may be due to the fact that a crop of sweet clover was plowed under in the spring of 1917; or it may be due to a combination of these two factors.

Plot.	FERTILIZER.	Fertilizer per Acre (Pounds).	YIELDS PER ACRE.			
			1917.[1]		1915.[2]	
			Corn (Bushels).	Stover (Pounds).	Corn (Bushels).	Stover (Pounds).
1	Nitrate of soda,	160	34.2	1,900	22.86	1,490
2	Dissolved boneblack,	320	18.1	1,600	10.00	760
3	No fertilizer,	–	12.7	2,400	8.50	615
4	Muriate of potash,	160	40.9	3,300	40.86	1,980
5	Lime,	800	13.8	1,700	5.29	635
6	No fertilizer,	–	13.9	1,500	10.93	720
7	Manure,	30,000	40.8	5,200	60.79	3,520
10	Nitrate of soda, Muriate of potash,	160 160	46.1	3,500	34.35	3,365
11	Dissolved boneblack, Muriate of potash,	320 160	46.3	3,300	37.58	3,250
12	No fertilizer,	–	15.7	2,100	16.50	960
13	Plaster,	800	21.7	1,400	10.92	805
14	Nitrate of soda, Dissolved boneblack, Muriate of potash,	160 320 160	36.0	5,400	35.15	3,400

[1] After plowing under a crop of sweet clover.

[2] Before plowing under a crop of sweet clover.

GRASS PLOTS.

The experiment in top-dressing permanent mowings with different materials used in rotation has been continued, but owing to the scarcity of potash this material was not applied the past season. In the following table will be found the fertilizer schedule and the yields per acre obtained on each for this year: —

FERTILIZERS.	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).
Barnyard manure,	3,741	1,487	5,228
Bone and potash,[1]	2,718	1,031	3,749
Slag and potash[1] (earlier ashes plot),	1,422	907	2,328

[1] No potash was applied in 1916 or 1917.

The average yields to date under the three systems of top-dressing are: —

	Pounds per Acre.
When top-dressed with manure,	6,006
When top-dressed with bone and potash,	5,824
When top-dressed with wood ashes (slag and potash now used),	5,496

The crop this year before cutting gave the appearance of a large yield, but the weights show a yield smaller than the average under each of the three systems of manuring.

Sulfate of Ammonia *v.* Nitrate of Soda as a Top-dressing for Permanent Mowings.

This experiment has been continued for ten years, and has for its object the comparison of nitrate of soda and sulfate of ammonia as a top-dressing for permanent mowings. All plots have received an equal application of potash and phosphoric acid. Owing to the scarcity of potash, none of this element was applied in 1916 or 1917. With favorable weather for the production of hay in 1916, a normal crop was obtained. In 1917, the second year the potash was omitted, with weather unfavorable for the production of good hay, the crop fell much below the normal.

Variety Test Work.

The testing of different varieties of potatoes, alfalfa and soy beans has been continued during the past year.

The statement made last year in regard to the relative merits of Grimm and Common alfalfa is further substantiated by the results obtained this year, viz., that our results do not show the Grimm to be any better than the Common.

During the past three years we have had under comparison with some standard varieties several seedling potatoes. None of these has given promise of being any better than the standard varieties.

The co-operative work with the United States Department of Agriculture in testing different varieties of soy beans has been continued.

Nine varieties of winter wheat were sown this fall, and it is planned to try a few varieties of spring wheat.

DEPARTMENT OF BOTANY.

A. VINCENT OSMUN.

The activities of the department of botany during the last year have continued mainly along two lines, viz., plant pathology and plant physiology. In addition, seed work, correspondence and reorganization of the mycological collection have demanded increased attention on the part of the staff.

A survey of the season of 1917 in Massachusetts indicates that, on the whole, conditions were somewhat unfavorable for the development of parasitic fungi. A late, wet spring, followed by a period of drought, checked many diseases which early in the season had threatened serious loss. Occasional short periods of high humidity were usually accompanied by high temperatures, which prevented development of potato late blight, and were followed by unusually bright weather not favorable to uninterrupted development of other diseases.

Early blight of potato inflicted more than the usual amount of damage before being checked by the dry weather of July. The tendency on the part of potato growers to delay the first application of Bordeaux mixture was responsible for much of the injury from this source. The first application, when the plants are not over 6 to 8 inches high, is one of the most important in the spraying schedule, as it is at this stage more than any other that a coating of the fungicide on the foliage is needed to prevent the early and late blight fungi from obtaining a start in the tissues. Late blight of potato was severe in the island counties and along the coast, owing to the continued high humidity throughout the season, the normal condition in that part of the State. The disease was present at scattered points in other parts of the State, but in few instances was injury to the vines sufficient to cause alarm. Later, however, this disease caused much rotting of tubers, owing to the wet condition of the soil, and the loss from this source among stored potatoes has been heavy. This condition is likely to seriously affect the quality of seed potatoes next spring. Potato scab was more prevalent than during the preceding few years, perhaps in part because of the greater number of amateur growers and the poor "seed" planted. Rhizoctonia of potato, though common, did relatively little damage. "Seed" disinfection as partial insurance against scab and Rhizoctonia is now generally practiced by experienced growers.

Bean anthracnose was everywhere in evidence on seedling plants early in the summer, but for the most part, owing to the dry period which followed, the disease did not progress, and was serious on the pods only in wet locations and in the island counties. Field experiments conducted by the department to determine the efficacy of various fungicidal spraying materials against this disease were without determinable results because of failure of the disease to develop. Stem and root rots of beans, caused by Fusarium and Rhizoctonia were of more frequent occurrence than usual, especially on wet and sour soils. These diseases present control problems of considerable importance, and should receive attention in the near future.

The onion crop suffered from a Macrosporium blight of the tops and Botrytis and bacterial rot of the bulbs, all of which apparently found favorable environment in the hot, wet period of August. The crop continued to rot badly in storage. The plans of the department include active investigation of onion diseases in 1918.

Fruit crops were as a rule freer than usual from disease. Peach leaf curl was, however, somewhat more abundant, though usually on trees not receiving a dormant spray. It is hoped that more growers in this State will adopt the practice of applying the dormant spray in the fall. This has proved successful where tried, and has several advantages over early spring spraying. When left until late winter or early spring there is always danger that a warm period may send the leaf curl fungus into the bud tissues beyond reach of the fungicide, and this probably explains occasional failures to control the disease by dormant spraying.

Sweet cherries suffered severely from brown rot, but this disease caused little damage to plums and peaches, except as it followed hail injury, when the loss from rotting became very heavy.

Two heavy hail storms, one in the latter part of July, the other early in August, seriously damaged fruit and tobacco in the Connecticut Valley and vicinity.

Apples and pears suffered comparatively little from disease. McIntosh and Fameuse were, in some orchards, badly scabbed. Our observations seem to indicate that there are individual cases of extreme susceptibility to scab among trees of these varieties, and that in such cases the usual fungicidal applications are insufficient to control the disease. Bitter-pit and fruit-spot were much less serious than in 1917, although both were of more frequent occurrence than usual.

Truck crop growers in the vicinity of Boston were heavy losers from downy mildew of cucumbers, which was severe both under glass and out of doors. Preliminary experimental spraying of greenhouse cucumbers for the control of this disease gave promising results. The work will be continued.

Celery, especially the Golden Self-Blanching variety, was almost a complete failure on some truck crop farms, owing to the severity of crown-rot and heart-rot. Growers are substituting other varieties because of the susceptibility of this variety to these bacterial diseases. However, owing to the desirable qualities of Golden Self-Blanching, an effort is being made, through selection of resistant plants, to develop a strain of this variety immune to these diseases. Early and late blight of celery inflicted but slight damage. This condition made very uncertain and unsatisfactory the results obtained from spraying with a number of fungicides on experimental plots located on three truck crop farms. This experiment will be repeated in 1918 with some modifications.

Heavy frost in September severely injured many crops. A large percentage of field corn failed to mature properly, and fodder corn was greatly reduced in feeding value. Injury to beans and potatoes was relatively small in most sections.

Although a record number of reports of the occurrence of plant diseases in the State was received, and correspondence was accordingly heavier than usual, this cannot be interpreted as indicating an abnormal season. It is explained, rather, by the war-time impetus given to gardening and general crop production by the publicity campaign waged in the State and throughout the country. Many reports were followed up only to find slight and isolated outbreaks of diseases. However, an awakened interest is indicated, and through it much may be accomplished in the way of suppression of diseases by education of the public in the use of known methods of control.

While this is recognized as extension work, it has always been conducted by the station staff because there has been no one specially assigned to act as extension plant pathologist. However, on November 1 Mr. W. L. Doran was appointed by the United States Department of Agriculture as extension specialist in diseases of truck crops, to work in co-operation with the department of botany. This arrangement will relieve station members of the department of much correspondence, and they should hereafter be able to give correspondingly more time to research. It will also enlarge the usefulness of extension work in plant pathology, and help to bring the department into closer touch with the problems of a larger number of growers.

The possibilities of research in plant pathology have been greatly enlarged by the addition of a field pathologist to the department staff. Formerly the amount of field work in pathological research which could be undertaken has been small, owing to the great amount of other work required of the department. This year spraying experiments on beans and celery were conducted in Amherst and Arlington, the latter in co-operation with the market-garden field station. In addition, investigations on diseases of lettuce and cucumbers were started in the greenhouses of several truck crop growers in Arlington and in the department greenhouse at Amherst. This feature of our work will be enlarged the coming year.

Extensive research on a new canker disease of roses, caused by the fungus *Cylindrocladium scoparium* Morg., has been under way for about a year, and results will be ready for early publication. This work was undertaken at the request of one of the largest growers of greenhouse roses in New England, who placed his equipment at our disposal for the carrying out of the more practical features of the investigation. It is believed that a satisfactory means of controlling the disease has been worked out.

For several years a disease of lawn grass, which is evidenced by the dying of the grass in round areas a foot or more in diameter, has been under observation. Repeated attempts to determine the cause of this trouble had failed to connect any pathogenic organism with it until last summer, when our efforts were rewarded by the isolation of a fungus which we have since proved to be the causal agent of the disease. The fungus proves to be an unnamed species of Sclerotium, and will be named and described in a later publication. Control measures are under investigation.

Investigations on rust of Antirrhinum, a serious disease of this floral crop both in the greenhouse and out of doors, have established a method of control under glass, and results will be presented for publication at an early date.

The complete results of the investigations on mosaic disease of tobacco were published in a bulletin issued during the year. On the completion of this work G. H. Chapman was assigned to a new project for the study of so-called "tobacco-sick soils," referred to in our last annual report.[1] This project has been established on an experimental basis. Three plots for study of fertilizer and soil reactions, and one for chemical treatment of soil infected with the root-rot fungus (*Thielavia basicola* (B. & Br.) Zoff), were conducted during last summer. Many soil samples have been taken for laboratory tests and much data gathered on various factors. Physiological studies of Thielavia are being made with a view to establishing a soil reaction favorable to the development of tobacco and unfavorable to the fungus. This work has awakened keen interest on the part of tobacco growers, who are more than ever looking to the station for help in solving some of their important problems.

The project for the study of the response of plants to light, in charge of O. L. Clark, was extended to include field work last summer. A number of crops were grown under cloth of different textures which cut off varying amounts of light, with a suitable check plot in the open. The tents were so designed as to insure only slight variations from normal of temperature and humidity. Preliminary results indicate that much of value may be expected from this feature of the investigation. In the greenhouse a study of the energy of assimilation under varying light intensities is being conducted. A method of obtaining a measure of total daily light also is under experimentation. Fundamental to the main problem, much work has been done in the laboratory on the response of stomata to changes in light intensity and light quality.

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[1] Twenty-ninth annual report, Mass. Agr. Expt. Sta., 1917, p. 63*a*.

The number of seed samples received for purity and germination tests showed an increase over former years, and more than the usual number of tobacco seed was sent in for cleaning and separation. At times the facilities of the department for doing seed work have been taxed to the limit, and should the work continue to grow, additional expenditures for equipment and help will be necessary.

In the work of reorganizing the mycological collection more than 10,000 specimens have been relabeled and placed in new packets of uniform size. Steel cases with a capacity of about 9,000 packets have been purchased. In order to house the complete collection under fireproof conditions about three more cases should be provided. The herbarium is a valuable adjunct to research in plant pathology and mycology; it could not be replaced if destroyed, and should be effectually guarded against fire and vermin.

In collaboration with the Plant Disease Survey of the United States Department of Agriculture, a survey of disease conditions within the State has been conducted for a number of years. This work recently has been reorganized at Washington, and its scope and usefulness will be greatly enlarged. It must be looked upon as forming a foundation for future work in plant pathology, and should be given the hearty support of the station. The writer frequently has urged the importance of making the disease survey a regular station project, and it is hoped that financial as well as moral support may be given to this work in the future.

DEPARTMENT OF CHEMISTRY.

J. B. LINDSEY.

The work of this department is divided into three distinct sections, — research, fertilizer, and feed and dairy.

1. Research Section.

(*a*) During the past year Dr. Lindsey and Mr. Beals have conducted experiments on the nutritive value of alfalfa; also considerable digestion work with sheep has been completed, including studies of the digestibility of Sudan grass, vinegar grains, alfalfa, sweet clover, carrots and Schumacher's Stock Feed. Experiments with horses on the digestibility and available energy in alfalfa, corn, oats, wheat bran, corn bran, brewers' grains, and in rations compounded from the same, have been completed, and other similar trials are in progress. Studies on the growth and feeding value of sweet clover and of Sudan grass have been made.

(*b*) Dr. Holland, assisted by Mr. Buckley, reports that the work on esterification methods for determining different fatty acids in butter fat has proved more successful than was anticipated. Instead of determining only lauric acid and possibly myristic acid from the insoluble acids as originally planned, it has been found possible to determine caproic, caprylic, capric, lauric and myristic acids quantitatively from the butter fat. The method is practicable and promises material assistance in dairy studies. A detailed account of the work has been accepted for publication in the "Journal of Agricultural Research."

A report has been prepared for publication in the same journal on the effect of air, light and moisture, singly and in combination, on olive oil. The investigation covered a period of six years, and furnished information of particular scientific interest and of practical value.

Co-operative work with the department of entomology on the problem "why insecticides burn" has been more extensive than usual, including complete analyses and solubility tests of a commercial sample of dry lead arsenate, lead arsenate paste and Paris green, and the preparation of calcium arsenate. In addition, dry lime sulfur, Stunga meal for earth worms, and the preparation of a new spray material for combating the red spider have received considerable attention.

The dehydrating action of lime sulfur has been investigated for Dr. Stone, formerly of the botanical department, the heat of combustion made of various samples for the microbiological department, analysis made and wax content determined of bee moth excrement for the entomological department, and analysis made of apple syrup for the horticultural department.

Miscellaneous work on arsenicals and the determination of invert and sucrose sugars in different varieties of strawberries have consumed considerable time.

(*c*) Messrs. Morse and Jones state that the relations between lime and soil acidity have been investigated on the soils of the fertilizer plots. The capacity of these soils to absorb calcium from different compounds, as well as the absorption of other similar bases, has been studied. The residual carbonate of lime existing in the soils, which at one time or another have been dressed with lime, has been determined. The true acidity or hydrogen ion concentration of water solution from the soils has been determined. The specific effects of different fertilizers used for years on the same plots have been compared in the foregoing investigations. A mass of data has been accumulated that is exceedingly difficult to reduce to practical applications.

The composition of the cranberry and its relations to storage and decay of the fruit has occupied the time of one of us since the cranberry harvest this fall. A study of the composition of the berries, month by month, as they have been received from storage, has been pursued. The variations in composition produced by storage at different temperatures, by asphyxiation in close packages and by decay have been compared. The rate of respiration or exhalation of carbon dioxide has been measured as a guide to the rate of chemical change taking place in the fruit after being picked.

The latter group of problems was taken up at the request of the Bureau of Plant Industry of the United States Department of Agriculture, and will necessarily extend into next year.

The soil problems must also continue in order to follow up promising leads arising from this year's work.

2. Fertilizer Section.

The work of the fertilizer section, in charge of Mr. Haskins, with Messrs. Walker, Allen and Scull as assistants, may be summarized as follows: —

(a) *Fertilizers registered.*

During the season of 1917, 100 manufacturers, importers and dealers have secured certificates for the sale of 512 brands of fertilizer, fertilizing materials and agricultural limes. They are classed as follows: —

Complete fertilizers,	175
Ammoniated superphosphates,	182
Ground bone, tankage and dry ground fish,	54
Wood ashes,	4
Chemicals and organic nitrogen compounds,	65
Agricultural limes,	32
	512

(b) *Fertilizers collected and analyzed.*

During the year 5,452 tons of fertilizer were sampled, necessitating the sampling of 12,801 sacks. One hundred and thirty-six towns were visited; 1,047 samples, representing 441 distinct brands, were drawn from stock found in the possession of 360 different agents or owners, and 626 distinct analyses were made. In addition, numerous samples of materials both single and mixed were officially collected and analyzed for farmers, so that the total number officially collected and examined was as follows: —

Complete fertilizers,	140
Ammoniated superphosphates,	198
Ground bone, tankage and dry ground fish,	72
Nitrogen compounds,	99
Phosphoric acid compounds,	28
Wood ashes,	31
Lime compounds,	34
	602

Full details regarding the fertilizer inspection work will be found in Bulletin No. 8, Control Series, published in December, 1917.

(*c*) *Other Activities of the Fertilizer Section.*

After the completion of the fertilizer inspection work an opportunity was found for the analysis of a great variety of fertilizing by-products which had been sent to the laboratory by farmers and farmers' organizations; also, during November, December, January, February and March, much co-operative analytical work was done on some of the problems of the Agricultural Department, particularly with reference to the analysis of crops grown in certain experiments both in the field and with pots. They may be briefly summarized as follows: —

Weights, dry matter and duplicate phosphoric acid determinations on 157 samples of rape.

Weights, dry matter and duplicate phosphoric acid determinations on 54 samples of millet seed and straw.

Weights and dry matter determinations on 392 samples of millet seed and 392 samples of millet straw; also 140 potash, 128 nitrogen and 22 phosphoric acid determinations were made on this series.

Thirty samples of soil and subsoil collected in various sections of the State have been analyzed for their content of acid soluble potash as well as for their mechanical analyses.

Five hundred and sixteen different substances have been received and analyzed for farmers and the various departments of the experiment station, and may be grouped as follows: —

Fertilizers and fertilizer by-products,	198
Lime products,	22
Soils for lime requirements and organic matter tests,	289
Soils for partial analysis, water soluble constituents,	5
	516

Time has been found for co-operative work with the Association of Official Agricultural Chemists, Mr. Haskins serving as referee on nitrogen for the year.

(d) *Vegetation Tests.*

In this division work has been continued, in co-operation with the basic slag committee of the Association of Official Agricultural Chemists, in the study of the availability of phosphoric acid in basic slag phosphate. The work this season was for the purpose of noting the residual effect of the different phosphates used during the preceding year.

One series of pot experiments with rape, comprising 18 pots, has been completed to study the availability of phosphoric acid in apatite and barium sulfide (Barium-Phosphate).

Another series with millet, comprising 10 pots, has been completed to study the crop-producing power of Nature's Wonder Mineral Plant Food, a ground metamorphic rock which has been advertised and sold under different names to a greater or less extent in Massachusetts for several years. The results have not been published, but fully substantiate previous experiments with the material which show that it possesses but little value as a source of plant food.

3. Feed and Dairy Section.

A summary of the work of the feed and dairy section, in charge of Mr. Smith, assisted by Messrs. Beals, Peables, J. B. Smith and J. T. Howard, follows: —

(a) *The Feeding Stuffs Law (Acts and Resolves for 1912, Chapter 527).*

During the past year 1,082 samples of feeding stuffs were collected at 140 places of business. About 1,400 brands have been registered and permits for sale issued. Four cases have been prosecuted where goods ran substantially below guarantee, and one case for failure to attach guarantee tags as required by statute. In addition, a number of samples have been drawn for the Federal government, and action is still pending. Although prices have ruled high and actual shortage has at times existed, goods offered have, with few exceptions, been as represented.

For the purpose of uniformity with other States requiring registration of feeding stuffs, the act has been amended so as to allow registrations to run with the calendar year instead of from September 1 to September 1.

The results of the year's work in detail can be found in Bulletin No. 7, Control Series.

(*b*) *The Dairy Law* (*Acts and Resolves for 1912, Chapter 218*).

(1) *Examination for Certificates.* — Forty-seven applicants have been examined and found proficient.

(2) *Inspection of Glassware.* — Seven thousand five hundred and twenty-two pieces of Babcock glassware have been tested for accuracy, of which 8 were condemned.

Following is a summary of the last seventeen years: —

Year.	Number of Pieces tested.	Number of Pieces condemned.	Percentage condemned.
1901,	5,041	291	5.77
1902,	2,344	56	2.40
1903,	2,240	57	2.54
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
1908,	2,713	33	1.22
1909,	4,071	43	1.06
1910,	4,047	41	1.01
1911,	4,466	12	.27
1912,	6,056	27	.45
1913,	6,394	34	.53
1914,	6,336	18	.28
1915,	4,956	4	.08
1916,	5,184	5	.10
1917,	7,522	8	.11
Totals,	70,600	1,993	2.82[1]

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[1] Average.

(3) *Inspection of Machines and Apparatus.* — During the months of November and December, Mr. J. T. Howard, the authorized deputy, inspected the machines and apparatus in 88 milk depots, creameries and milk inspection laboratories. Three machines were condemned as unfit for use, and minor repairs ordered in several others.

Following is a list of creameries, milk depots and milk inspectors' laboratories visited in 1917: —

1. *Creameries.*

LOCATION.	Name.	Manager or Proprietor.
1. Amherst,	Amherst,	R. W. Pease, proprietor.
2. Ashfield,	Ashfield Co-operative,	Wm. Hunter, manager.
3. Belchertown,	Belchertown Co-operative,	M. G. Ward, manager.
4. Cummington,	Cummington Co-operative,	D. C. Morey, manager.
5. Easthampton,	Hampton Co-operative,	W. S. Wilcox, manager.
6. Monterey,	Berkshire Hills Co-operative,	F. A. Campbell, manager.
7. Northfield,	Northfield Co-operative,	C. C. Stearns, manager.
8. Shelburne,	Shelburne Co-operative,	W. C. Webber, manager.

2. *Milk Depots.*

LOCATION.	Name.	Manager.
1. Boston,	Alden Brothers Branch,	Wm. Johnson.
2. Boston,	Boston Jersey Creamery,	T. P. Grant.
3. Boston (Dorchester),	Elm Farm Milk Company,	J. K. Knapp.
4. Boston (Charlestown),	H. P. Hood & Sons,	N. C. Davis.
5. Boston (Charlestown),	H. P. Hood & Sons, No. 2,	N. C. Davis.
6. Boston (Forest Hills),	H. P. Hood & Sons,	N. C. Davis.
7. Boston (Dorchester),	Morgan Brothers,	A. G. Johnson.
8. Boston,	Oak Grove Farm,	J. Alden.
9. Boston,	Plymouth Creamery Company,	W. J. Gardner.
10. Boston (Charlestown),	Rockingham Milk Company,	C. A. Bray.
11. Boston,	Turner Centre Dairying Association,	I. L. Smith.
12. Boston (Charlestown),	D. Whiting & Sons,	J. K. Whiting.
13. Boston (Jamaica Plain),	Westwood Farm Milk Company,	V. E. Clem.
14. Cambridge,	C. Brigham & Son,	J. K. Whiting.
15. Conway,	H. P. Hood & Sons,	F. E. Burnett.

2. *Milk Depots* — Concluded.

Location.	Name.	Manager.
16. East Watertown,	Lyndonville Creamery Association,	H. A. Smith.
17. Everett,	Frank E. Boyd,	F. E. Boyd.
18. Everett,	Hampden Creamery Company,	R. T. Mooney.
19. Lawrence,	Jersey Ice Cream Company,	J. N. Gurdy.
20. Lawrence,	Turner Centre Dairying Association,	F. M. Barr.
21. Lawrence,	Willardale Creamery,	F. H. Willard.
22. North Adams,	Ormsby Farms,	W. E. Penniman.
23. North Egremont,	Willowbrook Dairy,	D. Nanninga.
24. Sheffield,	Willowbrook Dairy,	F. B. Percy.
25. Shelburne Falls,	H. P. Hood & Sons,	R. E. Wetherbee.
26. Southborough,	Deerfoot Farms,	S. H. Howes.
27. Somerville,	Seven Oaks Dairy Company,	A. B. Parker.
28. Somerville,	Acton Farms Milk Company,	J. Colgan.
29. Springfield,	Tait Brothers,	H. Tait.
30. Waltham,	Manhattan Creamery,	A. W. Jenkins.
31. West Lynn,	H. P. Hood & Sons,	N. C. Davis.

3. *Milk Inspectors.*

Location.	Inspector.	Location.	Inspector.
1. Amesbury,	J. L. Stewart.	16. Gardner,	H. O. Knight.
2. Amherst,	P. H. Smith.	17. Greenfield,	G. P. Moore.
3. Attleboro,	S. Leiboff.	18. Haverhill,	J. A. Ruel.
4. Barnstable,	G. T. Mecarta.	19. Holyoke,	D. Hartnett.
5. Boston,	J. O. Jordan.	20. Lawrence,	J. H. Tobin.
6. Brockton,	G. E. Bolling.	21. Lowell,	M. Marster.
7. Cambridge,	W. A. Noonan.	22. Lynn,	H. P. Bennett.
8. Chelsea,	W. S. Walkley.	23. Malden,	J. A. Sanford.
9. Chicopee,	C. J. O'Brien.	24. Millbury,	F. A. Watkins.
10. Clinton,	G. L. Chase.	25. New Bedford,	H. B. Hamilton.
11. Dedham,	E. Knobel.	26. Newton,	A. C. Hudson.
12. Everett,	E. C. Colby.	27. North Adams,	C.T. Quackenbush.
13. Fall River,	H. Boisseau.	28. Northampton,	G. R. Turner.
14. Fitchburg,	J. F. Bresnahan.	29. Pittsfield,	B. M. Collins.
15. Framingham,	F. S. Dodson.	30. Plainville,	J. J. Eiden.

3. *Milk Inspectors* — Concluded.

Location.	Inspector.	Location.	Inspector.
31. Plymouth,	W. E. Briggs.	39. Ware,	F. E. Marsh.
32. Revere,	J. E. Lamb.	40. Watertown,	L. Simonds.
33. Salem,	J. J. McGrath.	41. Wellesley,	W. A. Berger.
34. Somerville,	H. E. Bowman.	42. Westfield,	W. H. Junkins.
35. South Hadley,	G. F. Beaudreau.	43. Winchendon,	G. W. Stanbridge.
36. Springfield,	S. C. Downs.	44. Woburn,	D. F. Callahan.
37. Taunton,	L. C. Tucker.	45. Worcester,	G. L. Berg.
38. Waltham,	G. D. Affleck.		

4. *Miscellaneous.*

Location.	Name.	Manager.
1. Boston,	Walker-Gordon Laboratory,	B. W. Nichols.
2. Boston,	Boston Laboratories, Inc.,	L. W. Lee.
3. Greenfield,	Franklin County Farm Bureau,	Miss M. Howard.
4. Springfield,	Emerson Laboratory,	H. C. Emerson.

(*c*) *Milk, Cream and Feeds for Free Examination.*

As in the past this department has continued to analyze samples of milk, cream and feeds sent by residents of the State where circumstances would appear to warrant this procedure. Work will not be done, however, which belongs more properly to a commercial chemist. During the year 202 samples of feeding stuffs, 744 samples of milk, 631 samples of cream, 3 samples of ice cream, 1 sample of condensed milk, and 2 samples of vinegar were analyzed.

(*d*) *Water.*

Sixty-six samples of water received in containers furnished by the experiment station were analyzed. A fee of $3 is charged for this service, and application for the analysis must be made in advance. Of the samples analyzed, 50 were from wells, 11 from springs, 4 from ponds or brooks, and 1 from pond ice. Water from public supplies is not analyzed, they being under the jurisdiction of the State Department of Health.

(*e*) *Testing of Pure-bred Cows for Advanced Registry.*

Four men have been given regular employment in conducting yearly tests of Jersey, Guernsey, Ayrshire, Shorthorn and Brown Swiss cows, and in addition extra men are employed as occasion demands. This work requires the presence of a supervisor at a farm for at least two days each month. The two-day test period forms a basis for computing the monthly milk and fat yield reported by the breeders direct to their respective cattle clubs. Following is a monthly summary of the work for the two-day yearly tests: —

Tabulated Results of the Work.

MONTH.	Number of Supervisors, Whole or Part Time.	NUMBER OF COWS TESTED.						NUMBER OF HERDS VISITED.					
		Guernsey.	Jersey.	Ayrshire.	Brown Swiss.	Short-horn.	Total.	Guernsey.	Jersey.	Ayrshire.	Brown Swiss.	Short-horn.	Total.
December,	8	190	126	36	–	–	352	30	8	6	–	–	44
January,	7	185	120	40	–	–	345	30	9	6	–	–	45
February,	9	186	131	35	–	–	352	31	9	6	–	–	46
March,	9	200	125	36	4	–	365	28	9	6	1	–	44
April,	13	199	113	39	5	–	356	27	9	6	1	–	43
May,	11	198	118	34	6	4	360	27	9	6	1	1	44
June,	8	190	100	43	7	5	345	27	9	6	1	1	44
July,	7	210	97	49	8	7	371	29	10	7	1	1	48
August,	9	199	88	50	9	7	353	29	10	7	1	1	48
September,	7	202	81	44	11	8	346	29	11	7	1	1	49
October,	9	202	74	55	13	9	353	31	10	8	1	1	51
November,	8	177	77	59	12	11	336	29	9	7	1	1	47
Totals,	–	2,338	1,250	520	75	51	4,234	–	–	–	–	–	553

The Holstein tests, usually based on a seven or thirty day period, require the presence of a supervisor during the entire test. It is becoming increasingly difficult to secure men for this work, as it does not warrant continuous employment. During the year 23 different men have been employed in these shorter tests, and 158 seven-day, 31 fourteen-day, 38 thirty-day, and 1 sixty-day tests, making a total of 228, have been completed. This work was conducted at 29 different farms.

4. Numerical Summary of Laboratory Work, December, 1916, to December, 1917.

There have been received and tested 66 samples of water, 744 of milk, 631 of cream, 3 of ice cream, 1 of oleomargarine, 1 of condensed milk, 202 of feedstuffs, 198 of fertilizers and fertilizer by-products, 22 of lime products, 289 of soils for lime requirements, 5 of soils for water soluble matter, 2 tests for arsenical poisoning, 1 of slum gum, 2 of vinegar, 1 of coal, 8 of lime-sulfur, 2 of arsenate of lead, 1 of Paris green, 2 of fruit preserves, 14 of strawberries and 10 miscellaneous.

The fertilizers officially collected numbered 1,047, and the cattle feeds, 1,082. There have also been tested, in connection with experiments in progress in the several departments of the station, 266 samples of milk, 152 of cattle feeds, 50 of fæces, 8 of urine, 157 of rape, 838 of millet seed or straw, and 30 of soils. The above totals 5,835 samples, and does not include the work of the research section nor that required by the dairy law.

DEPARTMENT OF ENTOMOLOGY.

A. I. BOURNE.

The work of the entomology department has followed in general lines similar to former years.

The correspondence has called for a much larger amount of time and effort than usual. Inquiries relative to over 250 different insects, as well as many questions on the proper use of various insecticides, and on pests other than insects, were received and answered. This increase was to be expected, in view of the fact that an unusually large number of persons throughout the State were taking up the cultivation of small gardens, many for the first time, in response to the National Campaign for Food Production. As a consequence, many complaints were received and information requested for the control of the most common of our insect pests, with which most of the experienced growers were already familiar, and concerning which in former years we received few, if any, complaints. It is safe to state that during the months of June, July and August the bulk of the daily correspondence was doubled, with a large increase during the rest of the season over former years.

Aside from the more common insects there were unusually severe outbreaks of several species which normally are of little or no economic importance.

The rose chafer, which usually causes more or less injury to grapes and ornamental stock, such as roses, etc., was this last season present in very large numbers, and proved a serious pest to almost all garden crops as well as to young fruit trees.

The chrysanthemum gall midge, a pest to be dreaded by growers of greenhouse chrysanthemums, owing to the enormous expense necessary to eradicate it once it has become firmly established, was reported from several points in the State, and caused much uneasiness on the part of florists.

The potato plant louse, normally present but in such small numbers that it can be entirely ignored, was this year so abundant and caused such rapid destruction in badly infested fields that especial attention on the part of the department was called for, and a bulletin delineating its habits and methods for its control was prepared and published.

During the early part of August the department received numerous reports of "greenish caterpillars" defoliating forest and shade trees, notably maples and beeches, from towns in Berkshire, Franklin and Hampshire counties. Upon a careful survey of the infested region the injury was found to be due principally to two species, — larvæ of the two-lined prominent moth and the green-striped maple worm. An indication of the nature and extent of this injury may be gathered from the following report: "Individual trees were often completely stripped of foliage, and, in some localities, the woods were so denuded that it appeared like late fall, when half to two-thirds of the foliage is gone."

Mention may here be made of several species of somewhat less importance, from an economic standpoint, but of interest from the fact that they had not been reported to this office before, or, at least, not as occurring in numbers enough to be a source of danger. In this class belong the grape-vine tomato gall midge, asparagus miner, parsnip web-worm and celery and parsnip plant louse. These, while not occurring in large numbers in any particular region, were quite generally present throughout the State.

Of the common pests, plant lice of all kinds, the squash-vine borer, flea beetles, cabbage worms of several kinds and the potato stalk borer were present in large numbers, and caused a corresponding amount of damage to crops.

As in former years, numerous species brought to this country from abroad on imported nursery stock were sent to this office by the inspectors for identification. This work, while calling for considerable expenditure of time, is, nevertheless, of value in order to keep the department in touch with insects which might, if they once became established, develop into serious pests. An instance of this is the so-called orange-tail moth, a European species closely related to the brown-tail moth, which was collected by the inspectors during this past year on stock from two different points abroad.

A new pest, the European corn borer, which from present knowledge is capable of causing severe injury to the corn crop, was this season found to be firmly established in the district immediately around Boston. Taking into consideration the damage to corn in the more or less restricted area infested during the past season, we can readily foresee the terrible losses it would cause should it ever be able to spread to the large corn fields of the West. A study of the nature of its attack and life history, together with a survey of the infested region, was undertaken, and a preliminary paper giving information thus far obtained has been published. More extensive work is planned for the coming season.

The other field work of the department has progressed satisfactorily. A bulletin on the "Control of the Red Spider in Greenhouses" is now ready for publication. Further work along the line of cultural methods of control is planned.

The experiments on the study of the causes of foliage injury from spraying with pure insecticides have been completed, and have progressed well with the use of the commercial materials.

The work on the control of the onion fly was checked somewhat during the past season because of an absence of the insects in the experimental plots and the immediate neighborhood.

Nearly all of the other lines of work are well along toward completion.

DEPARTMENT OF HORTICULTURE.

FRANK A. WAUGH.

During the year two new projects have been added to our research program. These are (*a*) studies in peach breeding and (*b*) critical studies of tree and leaf characters in varieties of fruits, especially apples and peaches.

Work has been practically concluded in the plant-breeding experiments with beans and peas, and an early publication of results is contemplated. Important practical results have been secured in the orchard management experiments, and material is being prepared for publication dealing with (*a*) orchard renovation, (*b*) soil management in the orchard and (*c*) varieties of fruits, especially apples.

A new experimental orchard of 275 trees has been planted in the town of Buckland as a part of the more extended research work on problems of reciprocal influences between stock and cion in graftage.

Experimental work with market-garden crops is getting under way at the market-garden field station in North Lexington, and we hope that this line of work will soon come to have considerable value to the State. Further experimental work is much needed with florists' crops and with small fruits, especially strawberries.

DEPARTMENT OF MICROBIOLOGY.

CHARLES E. MARSHALL.

The regular work of the microbiology department of the experiment station has been a study of soil fertility under the Adams fund. In addition to this there has been a limited allowance for milk investigations. The department has also received support under the De Laval fund, which has provided resources for the study of milk clarification.

The soil studies were diligently pursued throughout the year by Dr. F. H. H. van Suchtelen, who severed his connection with this institution Sept. 1, 1917. Dr. van Suchtelen, however, had reached the point where he had formulated certain directive principles which will be a great aid to the development and continuance of the problems involved. Dr. A. Itano was appointed to take up the work where Dr. van Suchtelen had dropped it, and has been pursuing it further and endeavoring to carry it through to its concrete application. In this work he has been assisted by Mr. George B. Ray.

Before Dr. Itano was appointed to take up the study in soil fertility from the microbiological standpoint he had been giving considerable time to the study of soy bean preparations for human food. In the carrying out of this work he not only tested out the work that had been done prior to his study, but he devised several new formulæ which possess much merit. The result of his efforts, which continued over about four months, has been published.

Dr. Itano, with the assistance of Mr. G. B. Ray and Mr. James Neill, has prepared cultures of nitrogen-gathering bacteria for legumes, and Miss Dondale has distributed these where requested. The number ordered may be of interest: —

For alfalfa,	202
For red clover,	17
For alsike clover,	4
For sweet clover,	13
For crimson clover,	14
For field beans,	366
For soy beans,	441
For peas,	80
For cow peas,	7
For vetch,	28
Total,	1,172

The laboratory has made itself useful to the health of the community through many tests made for physicians by Dr. Itano.

The past year milk studies outside of milk clarification were suspended for emergency food investigations. In the latter studies it has been aimed principally to survey the situation and gather material to outline the plan of study for curtailing loss in the canning of food. In this undertaking Mr. E. G. Hood and Mr. G. B. Ray have given most generously of their time, and have furnished valuable assistance. At the time of writing this report we are planning to make an intensive attack upon the problems of canning. The results accumulated thus far will simply be brought together in connection with the results we hope to secure in the future work.

Mr. E. G. Hood has also conducted many milk determinations for the town of Amherst, for individuals sending in samples and for dairy exhibits. He has tested for the town of Amherst 118 samples, outside material sent in, 32 samples, milk in dairy exhibits, 369 samples.

The De Laval studies have been pursued throughout the past year by these graduate assistants: Mr. E. G. Hood, Mr. R. C. Avery and Mr. S. G. Mutkekar. Miss Louise Hompe, Mr. H. A. Cheplin and Mr. J. E. Martin began work in September. Of these men, Mr. Avery enlisted for war service in July, Mr. Cheplin in November and Mr. Martin in December. Considering the difficulties under which we have been working, decided progress may be reported.

DEPARTMENT OF POULTRY HUSBANDRY.

H. D. GOODALE.

Egg Production.

This year's flock is superior to last year's in that a larger proportion matured earlier, with a corresponding increase in flock production early in the season. Thus the mean October production of pullets hatched March 18 to April 1 was nearly 12 eggs, as compared with 4 eggs for the flock of corresponding age a year ago after families of known poor producers were excluded from the latter.

Although production in the high strains is very satisfactory, there is room for further improvement, especially in regard to rate of production. Now that a satisfactory degree of maturity has been reached much more attention will be paid to rate, but slower progress may be expected because the demand for space made in the development of the non-broody strain forces us to reduce the flock of high winter layers to one-third its present size.

An intensive study of our data with relation to the winter cycle of egg production was made during the year. A paper embodying this work has been published. It was concluded, first, a winter cycle is a definite biological entity, best recognized in the individual by a pause (usually exceeding ten days in length, and beginning in December, January or, rarely, February) following an egg-production period of considerable length; second, monthly rate of production is not a good index of the winter cycle; third, many individuals lack the winter cycle and lay continuously throughout the winter; fourth, this cycle is perhaps a recessive Mendelian character.

Trap-nest work was begun last fall (1916) on Brown Leghorns in connection with the work on broodiness. Curiously enough, a type of winter egg record was secured from many individuals that has been practically absent from the Rhode Island Reds, and which we believe corresponds to the class designated as mediocre producers by Pearl. They should furnish important corroborative evidence regarding the inheritance of fecundity.

The trap-nested pullets were transferred again this year to roosting sheds, this time in July. We find this method a satisfactory solution for the problem of carrying the birds through the year and still having the houses ready for the pullets in September. We shall, however, make the transfer in June the coming season.

The flock of pullets bred for absence of broodiness numbers this year about 125 individuals. In addition, we have retained 40 non-broody hens for breeding purposes, besides a number of males from families of similar breeding. Among the families tested last season was one in which the ratio of broody to non-broody individuals was 1: 3, while several others had a ratio of 1: 1. The normal ratio for our flocks is 19: 1. Unfortunately, the exigencies of the situation have resulted in reduced winter egg production. However, no difficulties are anticipated in eventually bringing this strain to a plane equally high with that secured when birds are bred primarily for winter production.

As a part of the work on broodiness an endeavor is being made to produce a strain in which broodiness shall be as intensively developed as possible.

Up to the present the facilities afforded by the present plant have been fairly adequate for the work in breeding for increased egg production, since this period has been devoted primarily to a study of the problem rather than to an attempt to breed for increased egg production. The steps that must be taken to secure high annual production are perfectly well defined. Briefly, they involve the permanent combination in one strain of all those factors, *e.g.*, non-broodiness, high rate, etc., that make for high production. The chance of securing the proper combination in one individual is directly proportional to the number of individuals studied. It is probably not greater than 1 in 5,000. But since the genetic composition of the male cannot be directly observed, but must be inferred from a study of his female relatives, and since his sisters almost always differ from each other in several points, one is as likely as not to select a male corresponding to his poorest sister as to his best one. If, however, numerous matings are made and tested, the chances of mating good males to good females is increased in proportion to the number of matings made. Thus the length of the job of producing a strain averaging 250 eggs annually depends upon the scale on which operations are conducted.

We are sometimes asked why we do not keep our layers for more than one year. The answer is that the pullets require all the available space. Now the annual renewal of the laying flock is a large item on a commercial plant, and absolutely necessary with available strains of American breeds. However, there seems to be no biological barrier in the way of securing a strain that will lay heavily year after year.

The accumulation of data on hatching quality of eggs is being continued as a part of routine procedure, but it has been necessary to drop the attempt — as a separate piece of work — to produce a strain whose eggs all hatch.

The policy of rearing the chicks on clean ground, well isolated from other fowl, has continued to yield splendid results. Although no culling whatever was practiced during the growing season, less than 2 per cent. of the pullets were unfit for the laying houses. Moreover, such measures of isolation as it has been possible to maintain have thus far secured freedom from roup among the experimental pullets.

It has been determined that crossing over takes place in the sex chromosomes of the male fowl.

Student Work.

Each year several seniors undertake a minor problem of investigation from which interesting preliminary results appear. Thus Mr. Flint found that winter egg production in Rhode Island Reds was independent of temperature. Mr. Graham found that the length of a bird's laying period was the best index of total production, although the time at which a bird began laying (maturity) was also a good index. On the other hand, rate of production during the spring months did not prove to be a good index, contrary to the report of another station.

As a master's thesis Mr. Stewart made a study of the rate of growth of chicks in relation to time of hatching. Individual weights were made monthly on nearly a thousand chicks. Rate of growth diminishes progressively from March to May hatches. This work bears directly on time of maturity and hence on egg production.

DEPARTMENT OF VETERINARY SCIENCE.

JAMES B. PAIGE.

During the past year, in addition to carrying on the usual activities involved in the receipt and examination of specimens of pathological material constantly coming in, reporting upon the findings, and the usual correspondence incident to the work of the department among the stock owners of the State, there have been maintained three different lines of control and investigational work, namely: —

1. Testing of fowl for the detection of bacillary white diarrhœa.
2. Investigations relative to *Bacterium pullorum* infection.
3. The value of anti-hog cholera serum in the prevention of hog cholera.

1. Testing of Fowl for the Detection of Bacillary White Diarrhœa.

The blood testing has been done by Dr. J. B. Lentz, Dr. C. T. Buchholz and Dr. G. E. Gage. It was carried on by Dr. Lentz until July 1, when he enlisted in the national service for the duration of the war. He is now on leave of absence. Dr. Buchholz took charge of the work on July 1, continuing with it until September 15, when he resigned from the department to engage in general veterinary practice. At this date there was a suspension of the testing until it was taken up by Dr. Gage on October 22, and carried on throughout the remainder of the year.

Notwithstanding the several breaks and interruptions in the work during the year the records on file in the department show that there were collected and tested blood samples from 13,531 birds. These birds belonged to more than 103 different owners of poultry in 70 different cities and towns of the State. The average percentage of reactors among something like 26,000 birds tested since the routine test was started in 1915 has been found to be 13.5 per cent. It is gratifying to note, in the case of the second application of the test to flocks previously tested, in which more than half the birds gave a strong reaction, that the disease bacillary white diarrhœa has been eradicated.

2. INVESTIGATIONS RELATIVE TO BACTERIUM PULLORUM INFECTION.

The investigations relative to *Bacterium pullorum* infection have been in charge of Dr. G. E. Gage. Regarding these studies he reports, under date of November 22, as follows: —

The work bearing on the specificity of *Bacterium pullorum* antibodies, with special reference to the agglutinins, has been completed, and will be published in the near future. The results furnish data for a comparison of the *B. pullorum* antibodies with those of the *B. coli-B. typhi-B. dysenteræ* group of agglutinins, and also data for discussion concerning the diagnostic value of the agglutination test.

The problem concerning the production of toxin by *Bacterium pullorum* has received most of the time at my disposal for experiment station work during the past year. This has proven a very difficult task in that the determination of a uniform grade of toxin has been hard to obtain. Data, however, are at hand which are of interest in *Bacterium pullorum* studies, and will be ready for publication some time this fall. They will be published under some such heading as "The Toxicity of *B. pullorum* Products."

The investigation concerning the production of antibodies, with special reference to the potency and rate of production, started in August, 1916, is now being continued as outlined at that time. At the present time a large number of birds, descendants of especially immunized individuals, are on experiment. Attempts are being made to study the progeny this year to determine potency and rate factors of the agglutinins elaborated in such birds descended from stock known to have definite infection. This problem has a direct bearing upon the routine work of testing breeding flocks for indications of *Bacterium pullorum* infection.

3. The Value of Anti-hog Cholera Serum in the Prevention of Hog Cholera.

The hog cholera investigations, carried on by the writer, are being prosecuted according to the general plans outlined in an earlier report. They have for their object the determination of the value of anti-hog cholera serum in the production of immunity for the prevention of hog cholera, the best methods of application, and the development, potency and continuance of inherited immunity. For use in these studies a herd of from 75 to 150 pigs is kept that is fed largely upon raw garbage collected about the town.

BULLETIN No. 173.

DEPARTMENT OF AGRICULTURAL ECONOMICS.

THE COST OF DISTRIBUTING MILK IN SIX CITIES AND TOWNS OF MASSACHUSETTS.[1]

BY ALEXANDER E. CANCE, PROFESSOR OF AGRICULTURAL ECONOMICS, AND RICHARD HAY FERGUSON, EXTENSION PROFESSOR OF AGRICULTURAL ECONOMICS, MASSACHUSETTS AGRICULTURAL COLLEGE, CO-OPERATING WITH OFFICE OF MARKETS, UNITED STATES DEPARTMENT OF AGRICULTURE.

FOREWORD.

The facts presented in this bulletin show that the cost of distributing retail milk by more than 80 distributors, some of them producers, some of them dealers, was 2.64 cents a quart in 1914 and 1915. It cost 42 distributors in Worcester and Springfield 2.79 cents a quart on the average.

These costs included (1) all labor costs — labor hired, labor of the members of the family, labor of the operator and proprietor in preparing the milk for delivery, and delivering it (labor made up more than half of the total cost); (2) all depreciation or replacement costs on all buildings, equipment and horses used in preparation or delivery; (3) all maintenance charges, or cost of upkeep of plant and equipment — repairs, oil, bottles, etc.; (4) all overhead or fixed charges and all supplies used but once — rent, interest, taxes, insurance, license, soap, caps, light, fuel, stationery, bad debts, spoilage, etc. The charges made were adequate and the figures obtained mean that, according to the accounts and statements of 85 distributors, the average milkman in 1914 and 1915 was able to pay himself wages and interest and account for all expenses and losses when he received from his retail customers 2.64 cents more than he paid for a quart of milk delivered at his plant; or 2.79 cents if he lived in Springfield or Worcester.

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[1] Practically all of the data for this bulletin were personally collected by the late Professor Richard Hay Ferguson, who was responsible also for most of the tabulations and for much of the bulletin in its present form. Mr. Ferguson died Dec. 1, 1915. This bulletin was his last work.

Prices have risen since 1915. Labor and supplies of all kinds are higher. Just how much the increase has been cannot be stated with accuracy. Retail food prices have advanced nearly 30 per cent. Perhaps 25 per cent. will fully cover the advance in milk-distributing costs.

Assuming the increase to be 25 per cent. the cost of retailing milk in the fall of 1916 would probably average 3.30 cents per quart for all distributors here cited and 3.49 cents per quart for the milkmen investigated in Springfield and Worcester. The authors will not, however, vouch for these figures. Actual present costs may be higher or lower than 3.30 cents or 3.49 cents.

INTRODUCTION.

It is well known that for a number of years the price of milk to the consumer has been increasing. Not long ago milk was retailed at 6 cents a quart, whereas to-day the price is 9, 10 and, in many instances, 11 cents. Producers complain that notwithstanding the increased price paid by consumers they are, at the prices paid to them, producing milk at a loss and unless some change is made whereby they can get a fair return for their product, the whole dairy industry in Massachusetts is doomed. On the other hand the consumers view with alarm the increase in price and cannot understand why they must pay 10 cents a quart for milk when the producer is receiving but 4½ to 5½ cents net.

Location of Cities and Towns Covered in this Investigation.

THE PROBLEM.

The milk question has many phases and many relations. Some of these have been indicated in the very enlightening bulletin on the milk situation in New England, issued in June, 1915, by the Boston Chamber of Commerce.

The Massachusetts Agricultural College, in its outline of the problem, has recognized three important lines of study and investigation:

1. The cost and methods of production.
2. Collection and primary transportation of milk and cream.
3. Methods and costs of distributing; *i.e.*, preparing for delivery and delivering milk and cream.

Closely related with all three is the problem of milk inspection.

Problems 1 and 2 are quite as important as No. 3, the cost of distribution, but this preliminary study deals mainly with distribution and incidentally with transportation. Several studies have been made of the cost of producing milk in the North Atlantic States but, in the authors' opinion, none of these deal with the problem of milk production on the typical dairy farms of New England in a detailed and thoroughgoing way over a sufficiently long period.[1] Comparatively little serious work has been done on the methods and cost of transporting milk.

Co-operative Investigation.

The Department of Agricultural Economics of the Massachusetts Agricultural College and the Office of Markets of the United States Department of Agriculture formulated a plan for making an accurate, first-hand study of milk distribution in a number of Massachusetts cities and towns, perhaps the first study of its kind ever organized.

The data used in this study were collected by agents of the Department of Agricultural Economics and the Office of Markets during the fall of 1914 and the winter of 1915. Altogether, rather accurate data were obtained from 85 distributors of milk, each of whom was visited from one to several times in order to obtain as reliable figures as possible. Several of the tabulations were made by the Federal Office of Markets, where all the figures were checked.

Scope of the Investigation.

Recognizing the fact that the cost of distribution may vary according to the size and location of a town or city, as well as with the size and method of doing business, it was decided to investigate three groups of towns.

Amherst and Walpole, each having a population approximating 5,000, — the former a college town in the Connecticut valley and the latter an industrial center in the southeastern part of the State, — were chosen as typifying small town conditions in different parts of Massachusetts. Both Amherst and Walpole draw their supply of milk from the immediate neighborhood. The greater portion of Amherst's milk is distributed by dealers, while that of Walpole is marketed by the producers themselves.

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[1] Harwood, P. M.: What it costs to produce Milk in New England. Mass. State Bd. of Agr. Cir. No. 9. Boston, Mass., 1914. Hopper, H. A., and Robertson, F. E.: The Cost of Milk Production. Cornell University in co-operation with Jefferson County Farm Bureau, Bul. No. 357. Ithaca, N. Y., 1915. Lindsey, J. B.: Record of the Station Dairy Herd and the Cost of Milk Production. Mass. Agr. Exp. Sta. Bul. No. 145. Amherst, Mass., 1913. Rasmussen, Fred: Cost of Milk Production. New Hampshire Coll. and Exp. Sta. Exp. Bul. No. 2. Durham, N. H., 1913. Thompson, A. L.: Cost of producing Milk on 174 Farms in Delaware County, N. Y. Cornell Univ. Bul. No. 364. Ithaca, N. Y., 1915. Trueman, J. M.: Records of a Dairy Herd for Five Years. Storrs Agr. Exp. Sta. Bul. No. 73. Storrs, Conn., 1912.

Haverhill and Pittsfield, industrial centers of approximately 30,000 population each — the former in the northeastern part of the State, in the midst of good dairy farms which supply the requirements of the city, and the latter in the heart of the Berkshires in western Massachusetts surrounded mainly by the homes of summer residents and drawing its milk supply from a greater distance — form the second group.

Springfield and Worcester, commercial and manufacturing cities of over 100,000 population, constitute the third group, the one located in the Connecticut valley, where the land is given over chiefly to the raising of tobacco, onions and other intensive crops, while the other is situated in the center of Massachusetts' best dairying county. Naturally, in Worcester and Haverhill a rather large portion of the milk is distributed by the producers themselves. In some cases the producers distribute not only the product of their own dairies but also that of neighboring farmers, thus in a measure becoming middlemen.

TABLE I. — *Firms interviewed, classified by Location and Quantity of Retail and Wholesale Milk, Cream and Skim Milk handled daily.*

PLACE.	Total Dealers.	300 Quarts and under.	301-500 Quarts.	501-1,000 Quarts.	1,001-2,000 Quarts.	Over 2,000 Quarts.	All Wholesale.	Handling only Cream and Skim Milk.
Amherst,	5	3	2	-	-	-	-	-
Walpole,	5	3	2	-	-	-	-	-
Haverhill,	22	4	8	7	1	-	-	2
Pittsfield,	12	3	3	2	3	-	1	-
Worcester,	31	4	10	10	3	2	1	1
Springfield,	11	3	2	2	3	1	-	-
Totals,	86	20	27	21	10	3	2	3
Per cent. of number,	100	23	31	24	12	3.5	3	3.5
Routes,	170	22	38	42	38	25	2	3

In each locality sufficient typical distributors were interviewed to insure the reliability of the figures and the representative nature of the facts. The distributors interviewed and the volume of business represented were as follows: —

PLACE.	Distributors interviewed.	Quarts of Milk and Cream distributed daily.	Total Number of Distributors in Locality.	Total Quarts daily Distribution Estimates.
Amherst,	5	1,320	5	-
Walpole,	5	1,409	5	-
Pittsfield,	12	7,690	46	-
Haverhill,	22	10,828	40	20,000
Worcester,	31	22,809	167	75,000
Springfield,	11	10,149	110	65,000

In Amherst, Walpole, Haverhill and Pittsfield about 60 per cent. of the total milk distributed is represented. In Springfield there are approximately 65,000 quarts distributed daily, and in Worcester 75,000. The figures presented include approximately 16 per cent. of the Springfield distribution and 30 per cent. of that in Worcester.

Some idea of the size of the milk business in Worcester and Springfield and the number and character of distributors may be gained from Tables II. and III. These figures were obtained in April and September, 1916. It is interesting that Springfield is supplied from 694 sources, the milk passing through the hands of 608 distributors handling a daily average of 27 gallons each. The average milkman in Springfield sells 118 gallons of milk and cream daily; in Worcester, 107 gallons.

TABLE II. — *Springfield, Sources, Quantities and Methods of securing City Milk and Cream Supply.*

SOURCES OF SUPPLY.	Number.	APPROXIMATE DAILY QUANTITIES.		Number of City Dealers supplied directly.
		Milk (Gallons).	Cream (Gallons).	
Producers hauling to city,	15	1,025	25	-
Individual producers shipping to city,	650	14,480	-	-
Country creameries and milk stations,	24	-	500	-
Farmers' stations,	5	-	-	-
Totals,	694	15,505	525	560

TABLE II. — *Springfield, Number of Milk Distributors and Approximate Quantities handled* — Con.

CLASSES OF MILK DISTRIBUTORS.	Number of Distributors.	Number of Routes.	APPROXIMATE NUMBER OF GALLONS SOLD DAILY.						
			Raw Milk.	Pasteurized Milk.	Special Milk.	Fermented Milk.	Certified Milk.	Cream.	Total Gallons.
Producers: —									
Retail,	15	15	750	-	150	-	-	25	925
Wholesale,	2	2	285	-	50	-	75	-	410
City distributors: —									
Retail,	75	127	6,250	2,500	-	-	-	50	8,800
Wholesale,	18	-	1,250	1,000	-	300	-	325	2,875
Licensed retail stores,	400	-	950	750	-	-	-	60	1,760
Hotels, saloons and restaurants,	98	-	750	750	-	-	-	65	1,565
Totals,	608	144	10,235	5,000	200	300	75	525	16,335

TABLE III. — *Worcester, Number of Milk Distributors and Approximate Quantities distributed.*

KIND OF DISTRIBUTORS.	Number of Dealers.	Number of Routes.	AVERAGE NUMBER OF GALLONS SOLD DAILY.						PER CENT. OF TOTAL GALLONS SOLD.	
			WHOLE MILK.		SKIM MILK.		CREAM.			
			Wholesale.	Retail.	Wholesale.	Retail.	Wholesale.	Retail.	Wholesale.	Retail.
Producers,	80	89	875	2,260	6	6	9	9	28.2	71.8
City dealers,[1]	87	180	4,672	8,693	1,068	134	935	134	42.6	57.4
Totals,	167	269	5,547	10,953	1,074	140	944	143	41.6	58.4

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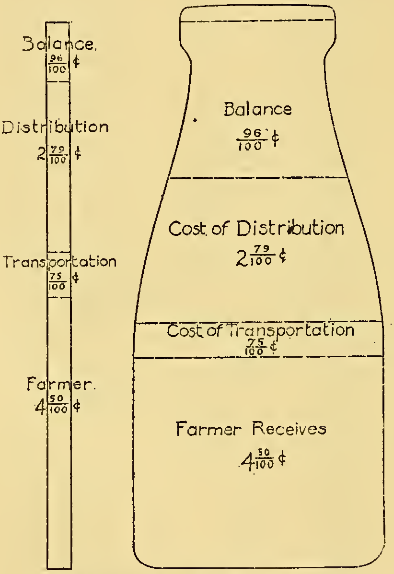
[1] Practically all the milk and cream sold by city dealers is shipped to the city by rail.

PROCESSING COSTS AND DELIVERY COSTS.

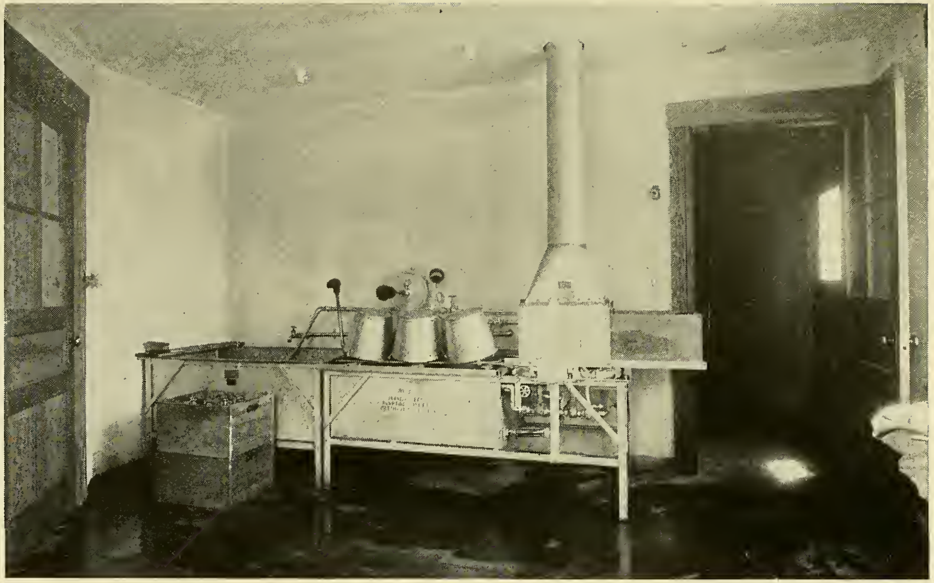
The costs of distributing milk fall naturally into two classes — preparation for delivery or processing, and delivery to customers. The transportation of milk from the producer to the dealer is an additional item of expense, but usually the producer delivers his milk to the dealer. In this study the transportation cost has not been considered. The analysis of costs begins with the preparation of the milk for delivery and ends with the collection of money from customers.

Simple as this analysis appears, a number of items cannot well be charged exclusively either to preparation or to delivery — administration and clerical expenses, light, telephone, etc.; insurance and taxes, perhaps; shrinkage, spoilage and bad debts. In the summary of costs these have been called "overhead" expenses; usually they might well be distributed between processing and delivery.



When the consumer pays 9 cents.

From the standpoint of health, pure, clean milk is as necessary as a good water supply. Milk just drawn from a healthy cow under sanitary conditions is at its best, and could it reach the consumer in this condition it would be ideal. To preserve it and to overcome the bad effects of unhealthy stock, unsanitary methods and conditions in the barn and reduce to a minimum the unavoidable deterioration in handling, transit and storage, milk has to be "prepared" for the customer. This preparation may be called "processing," and, so far as the distributors interviewed



Equipment every distributor should have.

were concerned, consists chiefly in cooling the milk and bottling, *i.e.*, washing, filling and capping the bottles. Milk is almost universally delivered to the consumer in bottles; in fact, only one instance of dipped milk was discovered; this was in Worcester.

In addition to this, however, some of the larger dealers clarify their milk by running it through a machine which removes the visible dirt, or pasteurize it to retard bacterial development. This materially adds to the cost of processing. Tables II and III show that only a minor percentage of the milk distributed in Springfield is pasteurized.

In Haverhill, of 20 distributors visited, but 2 had pasteurizers. In Springfield 16 were visited and but 1 had a pasteurizer and clarifier. In Worcester 35 were visited; 2 had pasteurizers and 2 others possessed clarifiers. Some few distributors produced milk under unusually good sanitary conditions, almost always keeping the bacterial count much lower than in ordinary milk. This they called "special" milk, and maintained that processing other than cooling and bottling was unnecessary and that pasteurizing was more likely to prove harmful than helpful to their trade. Under ordinary conditions the investment in processing machinery was very small indeed, and the labor involved in caring for the milk was confined to the most ordinary precautions to prevent souring.

DIFFICULTIES IN OBTAINING DATA.

Many difficulties were met in securing the necessary data to determine the cost of distribution. Very few producers or dealers kept proper books; in fact, any sort of bookkeeping was the exception rather than the rule. Complications also arose when the producer distributed the milk, for it was difficult to separate the items of production and distribution, the stable, shed, horse and harness being used for both. In many cases, therefore, estimates only could be given, but great care was taken that such estimates should cover the actual cost. The figures quoted are fairly accurate, and those on the cost of distribution of "special" milk can be relied upon in every detail, since most fortunately these distributors have kept accurate records for a period of several years.

Mixed Business. — The greatest problem, however, that confronted the investigators arose from the fact that in almost all cases the distributors not only deliver bottled milk directly to the individual consumer, but deliver wholesale milk both in bottles and in cases to other retailers and restaurants and also deliver cream both wholesale and retail. By good fortune figures were obtained from a dealer who kept accurate cost accounts and dealt entirely in wholesale milk. His accounts show that it cost him three-quarters of a cent ($0.0076) per quart to collect his milk from producers and distribute it in wholesale quantities. This figure is not applicable in most instances, however, for the reason that ordinarily the distributor does not go out of his way to deliver his wholesale milk; that is to say, his route is no longer and his apparent costs vary but little, whether he delivers retail milk only or adds a few wholesale deliveries. Careful thought indicates that an allowance of one-half cent per quart for wholesale milk delivered by a retail dealer covers the cost of this service in most instances; consequently this figure has been uniformly used.

This method of accounting, which very evidently lays the burden of costs on the retailed milk and rather arbitrarily establishes the costs of incidental wholesale distribution, is presented with full recognition of its weakness and its limitations. It does not mean that wholesale milk can be delivered at this cost, nor that a mixed business should not be considered on its merits; but it is manifestly unfair to assume that it costs as much to deliver 200 quarts at wholesale to two customers as to deliver 200 quarts at retail to 200 customers; and, since three-fourths of the quantity is retailed and nine-tenths of the equipment is for retailing, the arbitrary figures given are very reasonable interpretations of the facts.

The same question arises as to the delivery of retail cream. Based somewhat on the cost of delivering retail milk and estimating filling, capping, boxing and icing, loss of bottles and other contingent expenses, a charge of 3 cents per quart is deducted for its distribution. These deductions may be open to criticism but they were reached after making full investigations and obtaining the opinions of many distributors.

Analysis of Costs.

Cost data may be grouped under comparatively few heads: —

1. Investment in land, buildings, horses and all equipment that is more or less permanent in its nature.
2. Depreciation on buildings and equipment.
3. Maintenance of plant and equipment.
4. Circulating capital, *i.e.*, current operating supplies used but once — fuel, soap, ice, etc.; and "overhead," *i.e.*, fixed charges, rent, insurance, taxes, etc.
5. Labor.

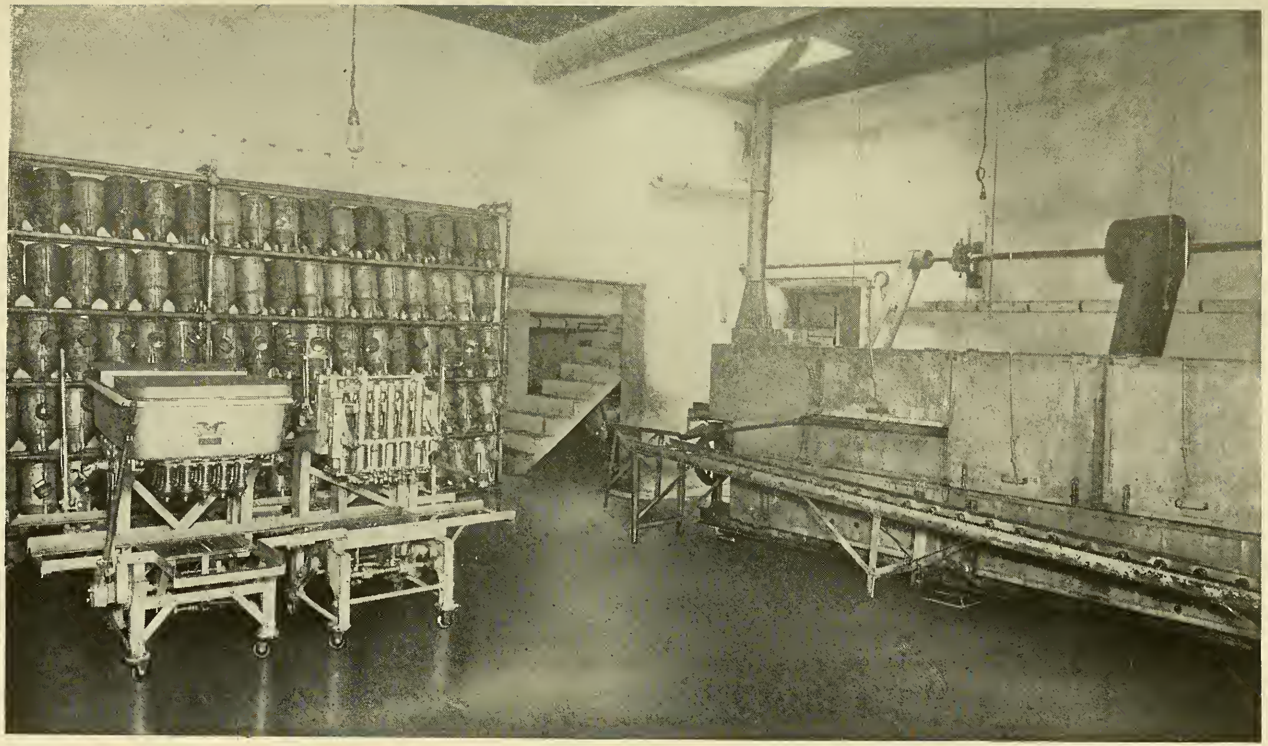
As previously noted these items may be assigned to processing, delivery and overhead or to processing and delivery.

Investment.

Investment includes the inventory value of real estate, horses and equipments used in the processing or delivery of milk and the housing of the horses and equipment. Depreciation was reckoned on all items of investment and was charged for one year. Some specific problems may be mentioned.

Depreciation Problems.

Horses. — No hard and fast rule was followed in determining the depreciation of horses. It was asserted by many that a horse worth $300 after giving ten years' service could be sold for $100; after five years' service, for $200, thus giving an annual depreciation in each case of $20. Some distributors affirmed that no depreciation of horse flesh could honestly be



The processing equipment of a progressive distributor.

charged, since they usually disposed of their horses after three or four years for more than they cost. Other animals eighteen and twenty years of age were giving good service.

Rate of Depreciation. — For these reasons each individual case was dealt with on its merits under this general formula: first cost of animal, less the selling price or the present worth, divided by number of years of service equals the annual depreciation. This method of calculation takes no account of losses by death; only horses now in service are considered. Where such losses had occurred in recent years some allowance was made, however. The figures obtained show that the depreciation of horse flesh increased in proportion to the size of the town or city, and also of the load hauled. In Amherst and Walpole annual horse depreciation averaged 7.5 per cent. In Worcester the average was 9.5 per cent.

Buildings. — To compute the investment in buildings and the necessary allowance for depreciation was also a source of some difficulty. In Walpole and Worcester a number of dairies were housed in basements, some in basements of residences. Moreover, the majority of the country dairies visited are in the barn, stable or shed, a partitioned space in these buildings being all that is considered necessary for the plant. In all these instances an estimate was made of the value of the whole building; this was multiplied by the fractional space occupied by the milk plant and to this was added the outlay for fitting up the plant itself. When the valuation was arrived at, 3 per cent., as a rule, was charged off for depreciation; 2 per cent. for taxes and insurance; and 5 per cent. for interest. This may be a trifle high, but in some cases the actual charges for taxes and insurance were more than 2 per cent.

Equipment. — The equipment varied exceedingly, but without exception fairly reliable data were obtained. No arbitrary rule was followed in computing the depreciation, since each individual item has a different period of service and these periods vary with the different plants and users. Many distributors had experience sufficient to enable the investigator to arrive at a fairly exact figure; in other plants estimates were necessary. In a number of cases the equipment was very meager and the methods employed crude; filling bottles by hand, heating water over a small gas burner, and washing bottles by hand were not unusual. Except in the case of the large dealers in the cities and a few of the more progressive producers who distribute, live steam was not used for washing or sterilizing and in several cases the heating apparatus was entirely inadequate.

Harness. — The almost unanimous opinion was that the life of a set of harness costing from $35 to $40 is five years, provided it is kept in good repair; the repairs usually amount to $5 a year. This bears out the statement of harness makers that harness costs $1 a month.

Wagons and Sleighs. — There was very little difference of opinion regarding the upkeep and life of wagons and pungs. The price of wagons ranged from $175 to $275, with a life of approximately eight years. They are usually varnished every year and painted and overhauled every alternate year. Pungs or sleighs cost an average of $50 and last about fifteen years, very little being spent on upkeep.

Other Equipment. — Boxes worth 80 cents to $1.25 are good for five years. There is a difference of opinion as to the relative merits of the wooden and the steel boxes. Five complete sets of cans are necessary for the average dealer, one set being replaced each year. This item, however, should be charged to transportation except in the case of the delivery of wholesale milk.

Maintenance.

Maintenance includes the expenditure necessary for the repair and upkeep of the buildings and equipment, including feed of horses and the loss of bottles and cans. In general, the outlay necessary to maintain the plant in working order is maintenance. Such items as grease and oil, veterinary service, shoeing, stable sundries, brushes, brooms, blankets, feed bags, carriers, hose, medicine, paint and other sundries required to keep up the buildings and equipment fall under this head.

Working Capital.

Working capital (or overhead and current supplies) includes such items as soap, ice, light, fuel, stationery, telephone, rent, insurance, taxes, interest on investment, spoilage, surplus, shrinkage and bad bills. It was difficult in many cases to separate these items, spoilage and surplus being included by some in shrinkage and by others in bad bills; fuel was consumed for other purposes than the dairy; the telephone included private use; and insurance, taxes and water rates often covered the residence or buildings used for other purposes in addition to the dairy. Assessed values and tax rates vary greatly, but in general 2 per cent. of the actual value was allocated to taxes and insurance. Insurance averaged about 1½ per cent. for three years. Interest was uniformly computed at 5 per cent. on the entire investment.

Labor.

Labor is classified as hired, home and personal. *Home labor* is labor provided by members of the family, such as assistance in the dairy or on the milk wagon, but more often in keeping the books. Usually home labor does not represent an expenditure, but is charged at the prevailing rates. *Personal labor* is the labor of the proprietor himself and is valued at his own estimate, never less than 25 cents per hour. In no case was the accepted estimate considered excessive or below a reasonable remuneration.

There is much individual variation in each of these items, especially among the producers who board the hired help. The wages paid varied from $25 to $35 per month and board; the estimates for board vary from $15 to $30 per month. The time, too, must often be distributed more or less unequally and arbitrarily between farm work and the preparation and delivery of milk. In all instances these adjustments were made carefully, but except as averages they cannot be considered in all respects infallible.

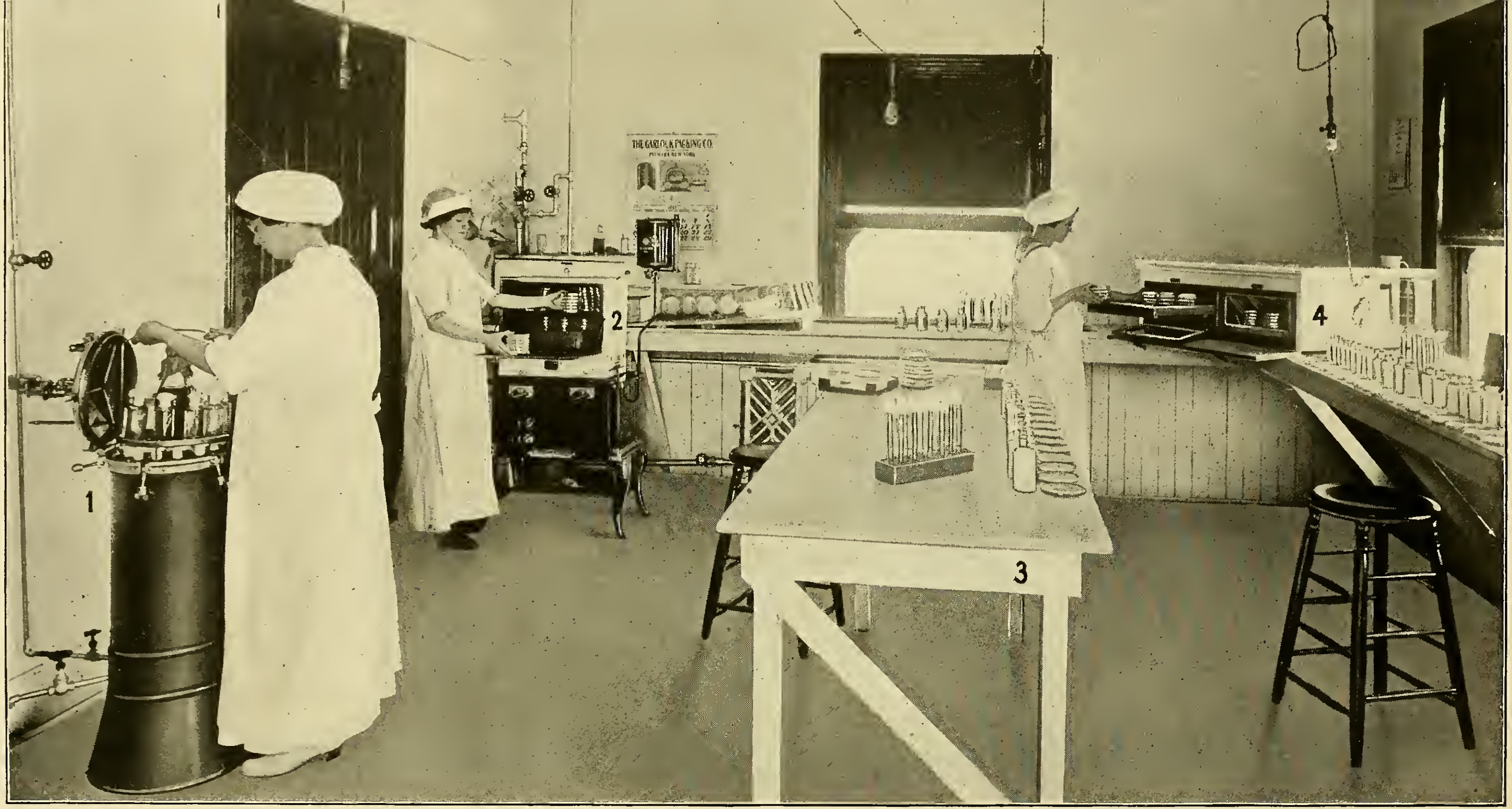
TABLE IV. — *Summary of Total Costs, and Cost per 1,000 Quarts, of distributing Milk and Cream (Forty-two Plants).*

	VALUE OF —																				TOTAL.	
	Horses.	Milk Sheds.	Ice Houses.	Stables.	Boilers.	Pumps.	Tanks.	Washers.	Fillers.	Pasteurizers.	Clarifiers.	Separators.	Ice Chests.	Harnesses.	Wagons.	Pungs.	Boxes.	Cans.	Office.	Sundries.	Per 1,000 Quarts.	Amount.
Investment: — Total,	$37,913 00	$26,002 00	$7,320 00	$24,333 34	$7,743 92	$1,560 00	$220 00	$4,755 00	$5,508 00	$4,310 00	$1,240 00	$410 00	$2,523 50	$6,121 00	$25,871 00	$6,781 00	$2,997 55	$2,629 70	$1,340 00	$545 00	–	$170,154 01
Per 1,000 quarts,	3 07	2 16	01	–	–	–	–	–	–	–	–	–	–	51	2 15	56	25	22	–	–	$14 15	–
Depreciation: — Total,	$3,971 71	$780 06	$359 60	$730 00	$764 58	$150 00	$16 00	$481 00	$509 73	$407 33	$116 00	$41 00	$203 73	$1,372 93	$3,787 85	$397 56	$676 82	$376 29	$132 00	$64 50	–	$15,338 69
Per 1,000 quarts,	33	00	03	–	–	–	–	–	–	–	–	–	–	11	31	03	05	03	–	–	$1 28	–
	Repairs.	Sundries.	Shoeing.	Feed.	Carriers.	Bottles.	Cans.															
Maintenance: — Total,	$0,896 31	$3,788 31	$4,193 80	$31,773 52	$184 67	$7,566 92	$493 85	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	–	54,897 41
Per 1,000 quarts,	58	31	35	2 64	02	63	04	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4 56	–
	Rent.	Soap.	Caps.	Ice.	Light and Oil.	Fuel.	Stationery.	Insurance and Taxes.	Interest.	Spoilage and Shrinkage.	Bad Bills.	Sundries.										
Circulating capital: — Total,	$3,324 00	$1,122 07	$2,519 19	$7,376 45	$1,578 30	$3,872 60	$1,931 45	$3,288 72	$8,326 21	$2,938 70	$6,560 52	$3,227 74	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	–	46,068 95
Per 1,000 quarts,	28	09	21	61	13	32	16	27	69	24	55	27	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3 83	–
Labor: — Total,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	–	163,697 45
Per 1,000 quarts,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	12 77	–
																					$22 44	$269,902 50

MILK DISTRIBUTED.

Retail: —	
Daily (quarts),	24,421.70
Yearly (quarts),	8,913,925.00
Wholesale: —	
Yearly (quarts),	2,890,595.00
Cream: —	
Yearly (quarts),	222,344 00
Total yearly cost of retail distribution,	$248,809 39
Cost per quart retail distribution (cents),	2.79

Miles travelled daily, retail,	834
Cost per mile (cents), retail,	81
Quarts per mile daily, retail,	29.20
Quarts per customer daily, retail,	1.18
Quarts per horse daily, retail,	174.40
Miles per customer, retail,	.04
Customers: —	
Wholesale,	498
Retail,	20,674



LABORATORY FOR EITHER CITY OR COUNTRY.

1. Steam heater for preparing agar. 2. Sterilizer. 3. Table for preparing samples to plate. 4. Incubator. (Courtesy of Boston Chamber of Commerce.)

Costs of Processing and Delivering summarized.

Table IV is an itemized summary of costs tabulated for 42 plants in Springfield and Worcester. Facts obtained in these cities are fairly comparable and the conclusions are quite as satisfactory as if the data for all six localities were included in the tabulations. The summary represents an annual business of approximately 9,000,000 quarts of retail milk, 3,000,000 quarts of wholesale milk and 222,000 quarts of cream out of a total distribution of about 15,000,000 quarts of retail milk, 4,700,000 quarts of wholesale milk and 300,000 quarts of cream — or about 60 per cent. of the total deliveries considered in this investigation. The milk of these 42 distributors was delivered to about 21,000 customers.

The total *investment* in plants and equipments amounts to about 1½ cents per quart of milk delivered. The largest investment items are milk sheds, horses and stables; boilers and ice houses come next but are comparatively insignificant.

The chief items of *depreciation* apply to horses, wagons and harness. These account for three-fifths of the total depreciation; another fifth is assigned to milk shed, stable, boxes, cans and boiler. By ascertaining the first cost, the present value and the time used, most of the items of depreciation are easily calculated.

Nearly $55,000 is classified under *maintenance.* More than three-fifths of this is for horse feed and just about 80 per cent. is for feed, repairs and horseshoeing. Lost bottles and cans are classified as maintenance and make up most of the remainder.

Circulating or working capital is here used to include overhead and fixed charges and supplies which are destroyed in one using. The largest item is interest on the investment, computed at 5 per cent.; the second is ice; and the third is bad bills. These items, with rent, insurance and taxes, fuel and loss by spoilage and shrinkage, account for 75 per cent. of this charge. Other items are soap, caps, stationery, light and oil. Labor of all kinds is by far the largest item, amounting to nearly three-fifths of the entire cost, or one and three-fifths cents per quart of milk retailed.

The average cost of processing and retailing milk is 2.79 cents per quart for an average daily delivery of 175 quarts of retailed milk per horse the year round. This cost is arrived at by deducting from the total expenses one-half cent a quart for the wholesale milk distributed and 3 cents a quart for retail cream.

TABLE V. — *Cost per Quart and Percentage of Total Cost for Depreciation, Maintenance, Circulating Capital and Labor.*

	Cost per Quart (Cents).	Percentage.
Depreciation,	.16	5.69
Maintenance,	.57	20.34
Circulating capital,	.48	17.06
Labor,	1.58	56.91
	2.79	100.00
Preparation,	.758	27.19
Delivery,	1.528	55.14
Overhead,	.492	17.67
	2.79	100.00

COSTS CLASSIFIED BY SIZE AND KIND OF BUSINESS.

Perhaps a better analysis of 80 plants is presented in Table VI. In this analysis an attempt has been made to classify the distributors by size of business and to set forth the items of cost under processing, delivery and overhead.

Only three plants do a business exceeding 2,000 quarts daily, hence the figures for these must be used with caution. Sixty plants do a mixed business, about three-fourths retail and one-fourth wholesale. Twenty plants deliver retail milk only. None of the all-retail plants do a daily business of 500 quarts. They are of one and two wagon capacity and so far as size of business is concerned should be classified with the "under 500" group.

The actual per quart costs, which include both *wholesale and retail* milk, run from about 1.6 to 2.9 cents per quart. The discrepancy between per quart costs given in Tables IV, V and VI is accounted for by the fact that in Table IV only 42 firms are considered and the cost of distributing all wholesale milk is computed at one-half cent per quart.

Plants of 500 to 1,000 quarts capacity do business most economically — 1.64 cents a quart for *all* milk delivered and 2.05 cents per quart for milk retailed. These costs are 25 per cent. and 22 per cent., respectively, below the average of all the plants investigated (2.21 cents for all deliveries and 2.64 cents for retailed milk). Plants of 1,000 to 2,000 quarts distribute for 1.82 and 2.23 cents per quart. The 27 plants of less than 500 quarts daily capacity average 2.04 and 2.66 cents a quart. The 3 plants doing a mixed business of more than 2,000 quarts daily and the 20 exclusively retail plants show the highest per quart costs for retailing — 2.92 and 2.93 cents for all expenses.

The overhead expense is the smallest item and in reality should be distributed between processing and delivery. It varies from 12.3 to 18.9 per cent. of the total cost in mixed, and 14.7 per cent. in retail business. This item seems to vary directly with the size of the business, *i.e.*, with the quantity handled. The processing expense runs from 24.7 to 31.8 per cent. of the total. In general this expense varies inversely with the quantity handled. Delivery costs a little more than one-half of the total, running rather uniformly around 55 per cent. The 1,000 to 2,000 quart group averaged 57.7 per cent. for delivery but the individual variations are wide. On the whole the figures show comparatively little correlation between costs and size of business.

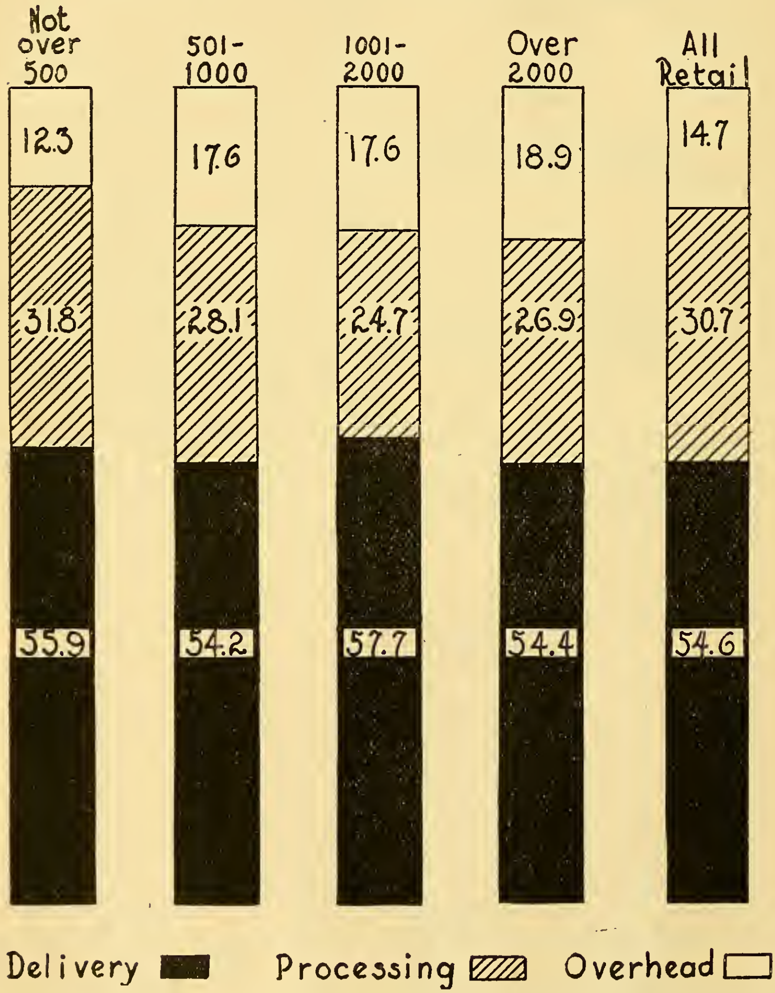
Investment and Size of Business.

The relation between size of business and average total amount invested in plant and equipment is of interest. The tabulations in Table VII., as might be expected, show a consistent correlation between investment and size of business. But when the investment per 1,000 quarts of milk distributed is considered, this consistent correlation is not shown. The strikingly high investment ($22.61 per 1,000 quarts) of the retail dealers is, perhaps, rather surprising when compared with an investment of $4.30 per 1,000 quarts in plants during a mixed business of the same size. Enterprises of the second and fourth classes have also a very high investment ratio. One might suppose that a milk-distributing plant could increase its volume of business by corresponding increase in plant, but an increase from an average of 360 quarts per day to an average of 710 quarts a day seems to multiply the total investment nearly six times, whereas men who do a retail business exclusively have four times the total investment of those who do a mixed business of the same size.

TABLE VI. — *Summary Statement of Expenses of Handling and Distributing Market Milk (Eighty Plants). Average Investments, Amounts handled and Items of Expenses classified in Groups.*

	SIZE OR KIND OF BUSINESS.									
Number of quarts sold daily,	Under 500.		500–1,000.		1,000–2,000.		Over 2,000.		All Retail.	
Number of establishments in each group,	27		20		10		3		20	
	Annually.	Daily.	Annually.	Daily.	Annually.	Daily.	Annually.	Daily.	Annually.	Daily.
Average number of quarts { Wholesale,	37,423	103	67,803	186	131,021	365	188,583	517	–	–
Average number of quarts { Retail,	94,125	257	191,067	523	422,912	1,159	879,163	2,409	100,664	276
										Weighted Average
PROCESSING INVESTMENT (AVERAGE PER PLANT),	$453 88		$836 89		$1,423 85		$11,756 67		$784 05	
Preparation expenses: —										
Depreciation and maintenance,	69 78		103 35		362 29		1,122 06		171 92	
Supplies,	283 64		415 92		982 49		1,026 96		315 19	
Labor,	506 14		677 83		1,174 06		5,062 67		423 74	
Average total cost for preparation,	859 56		1,197 10		2,518 84		7,211 68		910 84 }	.0064
Cost per quart,	.0065		.0046		.0045		.0067		.0090 }	
DELIVERY OR DISTRIBUTION INVESTMENT,	$112 10		$2,488 00		$3,855 05		$8,837 00		$1,492 94	
Delivery expenses: —										
Depreciation and maintenance,	222 86		414 10		730 26		1,851 75		310 85	
Supplies,	386 71		650 48		1,521 01		3,654 65		387 92	
Labor,	897 63		1,253 08		3,580 65		8,942 30		912 95	
Average total cost for delivery,	1,507 20		2,317 66		5,831 92		14,448 70		1,611 71 }	.01214
Cost per quart,	.0114		.0089		.0105		.0135		.0160 }	

Overhead Investment,	–	–	–	–	–	
Overhead expenses: —						
Administration and clerical salaries,	$163 13	$325 48	$844 35	$1,445 33	$164 07	
Light, telephone, stationery, etc.,	45 40	48 44	104 36	325 67	40 08	
Insurance, taxes, license,	15 15	38 80	210 93	630 62	28 85	
Shrinkage and spoilage,	23 08	61 65	100 85	992 67	38 30	
Bad accounts,	52 84	117 59	226 77	621 67	48 80	
Interest,	28 30	166 24	263 95	1,029 68	113 85	
Average total cost for overhead,	327 90	758 20	1,751 21	5,045 64	433 94	.0032
Cost per quart,	.0025	.0029	.0032	.0047	.0043	
Average total costs for preparation, delivery and overhead charges,	$2,694 66	$4,272 95	$10,101 97	$26,706 03	$2,956 49	–
Total costs per quart for preparation, delivery and overhead charges,	.0204	.0164	.0182	.0249	.0293	.0218
Total costs per quart for *retail* delivery, allowing .5 cent per quart for milk delivered at wholesale,	.0266	.0205	.0223	.0292	.0293	.0254



PERCENTAGES OF TOTAL COSTS PER QUART BY SIZE OF TOTAL BUSINESS

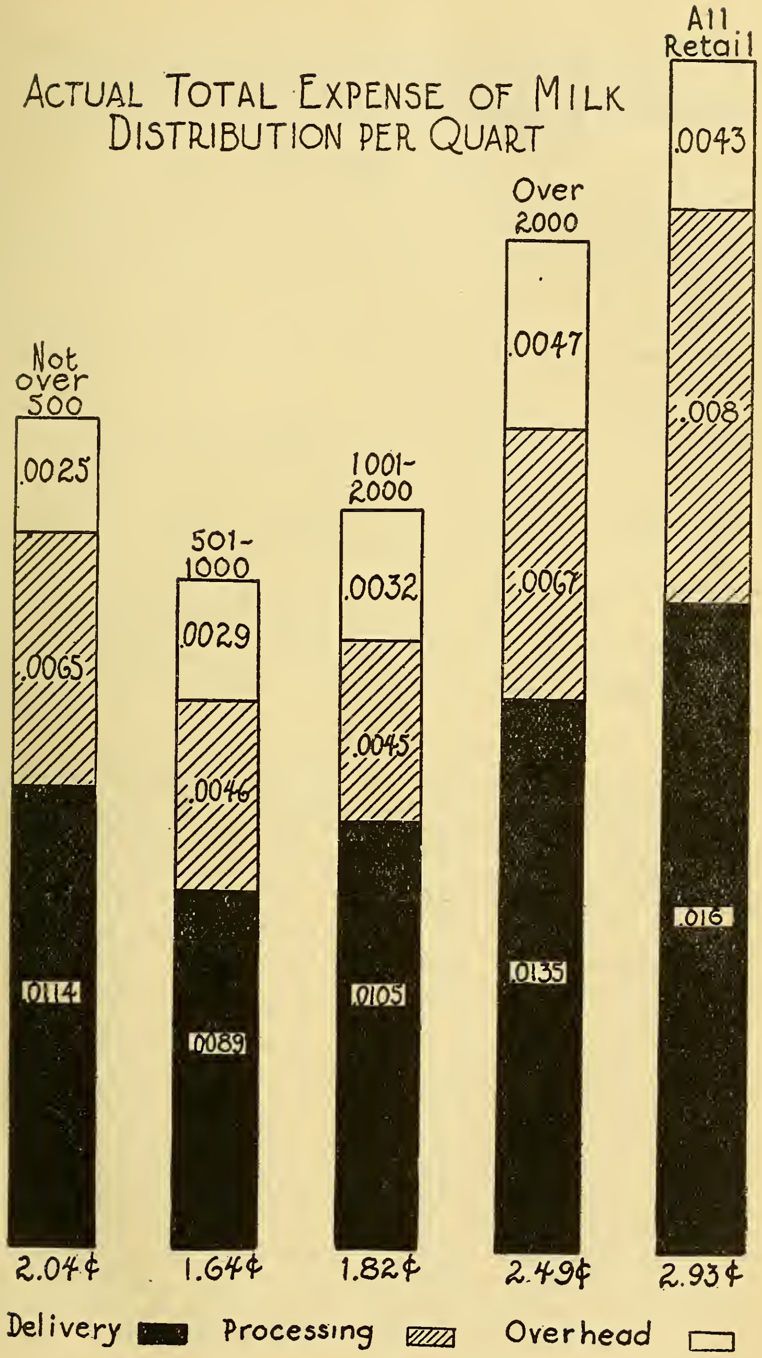

ACTUAL TOTAL EXPENSE OF MILK DISTRIBUTION PER QUART
Not over 500
.0025
.0065
.0114
2.04¢
501-1000
.0029
.0046
.0089
1.64¢
1001-2000
.0032
.0045
.0105
1.82¢
Over 2000
.0047
.0067
.0135
2.49¢
All Retail
.0043
.008
.016
2.93¢
Delivery
Processing
Overhead

TABLE VII. — *Percentages of Total Cost per Quart of Wholesale and Retail Milk (80 Plants), by Size or Character of Business.*

	I Under 500 Quarts.	II 500–1,000 Quarts.	III 1,001–2,000 Quarts.	IV Over 2,000 Quarts.	V All Retail.	Average.
Number of establishments,	27	20	10	3	20	-
Total cost,	$0 0204	$0 0164	$0 0182	$0 0249	$0 0293	$0 0218
Per cent.,	100	100	100	100	100	100
Processing expense,	$0 0065	$0 0046	$0 0045	$0 0067	$0 0090	$0 0064
Per cent.,	31.8	28.1	24.7	26.9	30.7	29.3
Delivery expense,	$0 0114	$0 0089	$0 0105	$0 0135	$0 0160	$0 01214
Per cent.,	55.9	54.2	57.7	54.2	54.6	55.7
Overhead expense,	$0 0025	$0 0029	$0 0032	$0 0047	$0 0043	$0 00322
Per cent.,	12.3	17.6	17.6	18.9	14.7	15.0
Investment: —						
Per plant,	$566	$3,325	$5,279	$20,594	$2,277	-
Per 1,000 quarts milk sold,	4 30	12 84	9 51	19 30	22 61	-

PERCENTAGE ANALYSIS OF COSTS.

The cost analysis presented in Table VIII shows the importance of labor both in processing and delivery, although the percentual importance varies greatly with the size of the business. The labor item differs also in the major processes of distribution. The relative importance of the labor item in the fourth group is the striking feature — 70 per cent. of the *processing expense* as contrasted with a maximum of 59 per cent. and a minimum of 46½ per cent. in the other groups. The labor factor in *delivery costs* is more uniform but even here the labor item in the fourth group reaches the maximum — 61.9 per cent.

It is significant that the labor item in *preparation* is lowest in the third and the all-retail groups, although the third group shows an actual processing cost of .45 cents, and the all-retail a cost of .90 cents per quart.

The principal point of emphasis in the overhead analysis, aside from the notable variation in the importance of the various items, is the high percentage of shrinkage and spoilage in the "over 2,000" group. Bad accounts average more than one-eighth of the overhead and, curiously enough, are percentually highest in Groups I and II, which show the lowest actual overhead. The interest item, of course, varies with the investment. Its percentual importance averages from about 9 per cent. in Group I, to 26.3 per cent. (three times as much) in the all-retail group.

TABLE VIII. — *Percentages of Costs in Relation to Size of Business. Amounts handled and Items of Expenses classified in Groups.*

	PERCENTAGES ACCORDING TO SIZE OR KIND OF BUSINESS.				
	I	II	III	IV	V
Number of quarts sold daily, . .	Under 500.	500-1,000.	1,001-2,000.	Over 2,000.	All Retail.
Number of establishments, . .	27	20	10	3	20
Average per cent. quarts sold daily: —					
Wholesale, ...	28.4	26.1	23.6	17.6	-
Retail, ...	71.6	73.9	76.4	82.4	100.0
Preparation expenses in per cent. of total.	31.8	28.1	24.7	26.9	30.7
Depreciation and maintenance, .	8.1	8.6	14.3	15.6	18.9
Supplies, ...	33.0	34.7	39.1	14.2	34.6
Labor, ...	58.9	56.6	46.6	70.2	46.5
Delivery expenses in per cent. of total,	55.9	54.2	57.7	54.2	54.6
Depreciation and maintenance, .	14.8	17.8	12.5	12.8	19.3
Supplies, ...	25.7	28.1	26.1	25.3	24.1
Labor, ...	59.5	54.1	61.4	61.9	56.6
Overhead expenses in per cent. of total,	12.3	17.6	17.6	18.9	14.7
Administrative and clerical salaries,	49.8	43.0	48.2	28.6	37.8
Light, telephone, stationery, . .	13.8	6.4	6.0	6.5	9.2
Insurance, taxes, license, . .	4.6	5.1	12.0	12.5	6.6
Shrinkage and spoilage, . . .	7.0	8.1	5.8	19.7	8.8
Bad accounts, ...	16.1	15.5	13.0	12.3	11.3
Interest, ...	8.7	21.9	15.0	20.4	26.3
Expenses in per cent. of receipts: —					
Preparation or processing, . .	7.9	5.8	5.0	8.4	9.4
Delivery, ...	13.9	11.1	11.6	17.0	16.7
Overhead, ...	2.9	3.4	3.3	5.7	4.3
Total expenses in per cent. of receipts,	24.7	20.3	19.9	31.1	30.4

The relation of costs to receipts is the really significant fact to the distributor. Costs run from a minimum of 19.9 per cent. to a maximum of 31.1 per cent. of total receipts. This means that the costs of the all-retail and "over 2,000" groups, for example, absorb 30 to 31 per cent. of the total receipts, a portion more than 50 per cent. greater than the part taken by the second and third groups.

This percentage which the expenses bear to receipts may be called the operating ratio. It is lowest in Groups II and III and highest in Group IV. The lower the ratio the more economical the operation of the plant. The operating ratio in any business is very significant. In milk distribution 20 per cent. is probably a low ratio and 30 per cent. a high ratio, but much more accounting must be done to determine this. In all instances the more expensive distribution is due both to higher processing and higher delivery costs and, in the fourth and all-retail groups also to higher overhead expenses.

Comparative Costs by Localities.

Table IX presents comparative cost data by towns. In these figures no attempt has been made to separate costs into processing and delivery. All the firms operating in Amherst and Walpole are in the "500 quarts or under" class; all but three of the Haverhill and Pittsfield firms are distributing less than 1,000 quarts per day; hence the firms interviewed doing a daily business of 1,000 quarts and more are almost all in Springfield and Worcester.

The data show plainly the greater cost per quart in the two larger cities, a cost which is seen in practically all items entering into distribution. Few conclusions of significance as regards variations by localities can be drawn from the figures giving total locality costs.

TABLE IX. — *Comparative Investment, Costs, Quantities and Customers served in Six Towns and Cities (Eighty-six Distributors)*

CITY OR TOWN.	INVESTMENT.					DEPRECIATION.			
	HORSES.		Buildings.	Equipment.	Total.	Horses.	Buildings.	Equipment.	Total.
	Value.	Number.							
Amherst,	$1,200 00	6	$2,210 00	$1,932 00	$5,342 00	$104 16	$214 33	$243 24	$561 73
Walpole,	2,320 00	9	8,600 00	1,900 20	12,820 20	161 07	223 00	232 33	616 40
Haverhill,	10,844 00	48	21,591 66	19,262 92	51,698 58	1,315 40	610 65	2,450 19	4,376 24
Pittsfield,	9,600 00	39	9,840 00	11,690 15	31,130 15	937 69	306 20	1,777 31	3,021 20
Springfield,	11,350 00	47	19,732 00	27,282 65	58,364 65	1,445 71	594 96	3,579 04	5,619 71
Worcester,	26,563 00	100	37,823 34	47,403 02	111,789 36	2,526 00	1,274 70	5,918 28	9,718 98

Table IX. — *Comparative Investment, Costs, Quantities and Customers served in Six Towns and Cities (Eighty-six Distributors)* — Con.

City or Town.	Maintenance.	Circulating Capital.	Labor.				Total Cost.	Number of Dealers.
			Hired.	Home.	Personal.	Total.		
Amherst,	$1,141 22	$1,068 48	$3,491 02	$471 32	$1,635 08	$5,597 42	$8,368 85	5
Walpole,	2,291 22	2,262 37	-	-	-	5,827 69	10,907 68	5
Haverhill,	15,773 94	14,344 24	15,688 75	2,209 30	17,678 57	35,576 62	70,071 04	22
Pittsfield,	10,334 85	9,131 62	15,656 41	733 18	12,542 09	28,931 68	51,419 34	12
Springfield,	19,543 48	16,587 05	49,491 55	-	12,717 47	62,209 02	103,959 26	10
Worcester,	35,353 93	29,481 98	53,408 96	6,525 70	31,453 77	91,388 43	165,943 32	32

TABLE IX. — *Comparative Investment, Costs, Quantities and Customers served in Six Towns and Cities (Eighty-six Distributors)* — Con.

CITY OR TOWN.	MILK AND CREAM DISTRIBUTED.				YEARLY COST OF DISTRIBUTION.		RETAIL.		
	RETAIL MILK.		WHOLESALE MILK.	CREAM.					
	Daily (Quarts).	Yearly (Quarts).	Yearly (Quarts).	Yearly (Quarts).	Retail Cost.	Cost per Quart (Cents.)	Quarts per Horse.	Quarts per Mile.	Quarts per Customer.
Amherst,	1,050.0	383,250	87,600	10,950	$7,775 73	2.03	175.0	17.9	1.235
Walpole,	1,289.0	470,485	29,200	13,140	10,643 68	2.26	143.2	23.8	1.025
Haverhill,	8,232.0	3,004,680	925,000	22,565	64,769 09	2.16	176.3	21.4	1.299
Pittsfield,	5,508.7	2,010,675	759,200	37,139	46,609 17	2.31	141.2	21.6	1.276
Springfield,	8,612.7	3,143,640	367,350	193,515	96,297 36	3.06	183.2	37.9	1.106
Worcester,	15,809.0	5,770,285	2,523,245	28,829	152,512 03	2.64	170.0	28.0	1.227
	40,501.4	14,783,015	4,691,595	306,138	$378,607 06	2.56	-	-	-

TABLE IX. — *Comparative Investment, Costs, Quantities and Customers served in Six Towns and Cities (Eighty-six Distributors)* — Con.

CITY OR TOWN.	MILES TRAVELED.		Cost per Mile.	CUSTOMERS SERVED.			SELLING PRICE OF MILK.		COST PRICE OF MILK.		Number of Routes.	Miles per Retail Route.
	Daily.	Per Customer.		Retail.	Wholesale.	Per Mile.	Wholesale.	Retail.	Collected.	Delivered.		
Amherst,	58.5	.068	$0 36	850	7	14.6	$0 0700	$0 08	-	$0 050	6	9.7
Walpole,	54.0	.042	54	1,257	4	23.3	0700	09	-	055	7	7.7
Haverhill,	395.0	.060	44	6,513	88	16.7	0700	08	$0 050	055	35	11.3
Pittsfield,	254.0	.058	50	4,317	69	17.2	0600	08	045	050	23	10.9
Springfield,	227.0	.029	1 16	7,784	95	34.7	0750	09	045	050	33	7.2
Worcester,	565.0	.042	74	12,890	403	23.5	0625	08	045	050	63	8.2

The comparative analysis of costs, including both processing and delivery, of retailing milk by cities and towns is exhibited in Table X. Before comparing localities it may be well to note that by far the most important item is labor, which varies from one-half to more than two-thirds of the whole distributing cost. This includes only man labor, horse labor being carried in the other items. This expense is greatest in Springfield, where it amounts to nearly 2 cents a quart, and lowest in Haverhill, where it is scarcely more than 1 cent.

Depreciation is the smallest charge, and runs about 6 per cent. of the total; actually it is lowest in Haverhill and highest in Springfield.

Maintenance and circulating capital show great relative variation. Both are relatively and actually lowest in Amherst and actually highest in Worcester and Springfield. The two charges amount to .52 cents a quart in Amherst, .85 in Walpole, .88 in Pittsfield, .92 in Haverhill, 1.03 cents in Worcester and 1.04 cents in Springfield. In general these items increase with the size of the town.

Amherst v. Walpole.

Amherst seems to process and distribute its supply of milk more economically than Walpole, notwithstanding the labor bill is slightly higher. Omitting cream, our figures show in round numbers 500,000 quarts of wholesale and retail milk delivered yearly in Walpole and 471,000 in Amherst. On this basis, Walpole's labor costs $11.65 per 1,000 quarts, and Amherst's $11.87; for retailed milk the labor expense is $12.58 per 1,000 quarts in Walpole and $13.69 in Amherst. Hired help is a little cheaper and more plentiful in the eastern part of the State, though the personal labor in both towns was computed at 25 cents per hour. The time occupied in delivery is the same, though the average milk route in Walpole is 25 per cent. shorter. Walpole serves more customers per wagon, 180 to 143 for Amherst, but delivers less milk per customer.

The dealers in Amherst, however, expend less for maintenance and working capital. The lower maintenance is due in part to the greater load per horse, the average retail load per horse being 175 quarts, in contrast with 143 quarts in Walpole. It must be noted, however, that Walpole hauls more per wagon — including wholesale milk and cream, 234 quarts to 214 for Amherst; the explanation is a two-horse wagon. In working capital there is a margin of .19 cents per quart (43 per cent. less) in favor of Amherst. Table X shows that these two items amount to nearly 40 per cent. of the total in Walpole as compared with less than 26 per cent. in Amherst.

With the exception of the items *stationery* and *shrinkage*, the Amherst figures for circulating capital show a big saving. The greater stationery charge is accounted for by the use of tickets by several of the Amherst dealers. The wisdom of this expenditure is justified by the small loss in bottles and a minimum loss by bad debts. It cost the five Walpole dealers $340 a year for bottles, or 72 cents per 1,000 quarts of retail milk delivered.

TABLE X. — *Comparative Distribution and Analysis of Costs per Quart of Retail Milk distributed, absolutely and by Percentages (Six Cities and Towns).*

	AMHERST.		WALPOLE.		HAVERHILL.		PITTSFIELD.		SPRINGFIELD.		WORCESTER.	
	Per Cent.	Cost per Quart.	Per Cent.	Cost per Quart.	Per Cent.	Cost per Quart.	Per Cent.	Cost per Quart.	Per Cent.	Cost per Quart.	Per Cent.	Cost per Quart.
Depreciation,	6.68	$0 00136	6.57	$0 00148	6.29	$0 00139	5.87	$0 00136	5.42	$0 00166	5.87	$0 00155
Maintenance,	13.66	00278	18.45	00417	22.73	00487	20.09	00465	18.10	00554	21.25	00561
Circulating capital,	12.18	00247	20.97	00438	20.60	00448	17.75	00412	15.96	00488	17.77	00469
Labor,	67.48	01369	54.01	01258	50.38	01086	56.29	01307	60.52	01852	55.11	01455
Totals,	100.00	$0 02030	100.00	$0 02260	100.00	$0 02160	100.00	$0 02320	100.00	$0 03060	100.00	$0 02640

Five Amherst dealers expend $140.69 for bottles, or 37 cents per 1,000 quarts of retail milk; this includes one dealer who does not use tickets. Eliminating this dealer for the sake of accurate comparison, the results may be presented in tabular form, as follows: —

Dealers in —	Number.	Distribute 1,000 Quarts.	Expend for Bottles.		Bad Debts.	
			Total.	Per 1,000 Quarts.	Total.	Per 1,000 Quarts.
Walpole, ...	5	470.5	$340 00	$0 72	$182	$0 40
Amherst using tickets, . .	4	346.7	133 40	38	31	09

It is significant that of $82 reported as lost through bad debts by Amherst distributors, $51 were reported by one dealer who did not use the ticket system. Comparing the figures of Amherst and Walpole dealers who do and who do not use tickets, it appears that where five Walpole dealers using no tickets suffer by bad debts a loss of 40 cents per 1,000 quarts of milk sold at retail, and one Amherst dealer loses similarly 62 cents, the four Amherst distributors using tickets have but 9 cents of bad debts for each 1,000 quarts retailed.

Under the ticket system the cost of collection is somewhat less, but since the drivers do the collecting it is difficult to approximate this difference. Tickets, of course, mean cash in advance; just how long in advance depends on the price of milk, and the amount used per family, since tickets are usually sold in $1 strips. The price per quart is exactly the same, whether the customer buys tickets in advance or pays in currency when the milk is delivered.

Ice cost Walpole dealers $1 per 1,000 quarts ($0.001 per quart) of milk, and the Amherst dealers 80 cents per 1,000 quarts ($0.0008 per quart).

Haverhill v. Pittsfield.

The difference in the figures for these towns is not marked. Pittsfield expends a very little less per quart for maintenance and circulating capital, but this is more than offset by higher labor costs. Labor is comparatively expensive, due to the competition of the summer homes in the vicinity.

Although Haverhill distributed milk at a lower cost per quart than any of the four cities, it was not at the expense of service, but rather as the result of the low labor cost coupled with the number of quarts delivered per horse, in other words, by getting the best service out of the horse. Haverhill averages 176.3 *retail* quarts per day per horse, while Pittsfield averages but 141.2 quarts per horse. Moreover, Pittsfield distributors deliver more cream and wholesale milk per route to a smaller number of customers than do Haverhill milkmen — about 100 quarts as against 75 for Haverhill.

It may be said in passing that the milk supplied by Haverhill dealers is exceptionally pure and clean. These qualities are popularly supposed to be expensive. If they are, Haverhill dealers have met the increased cost by economies elsewhere. The city's entire supply comes from local producers. Thus any impure milk can be at once traced to the source of supply and the producer of exceptionally clean milk be quickly recognized. Frequent inspections and monthly tests by a competent bacteriologist are made. The methods of inspection and the publication of the results of the monthly bacterial analyses have educated the Haverhill public to appreciate the value of clean milk and have stimulated a healthy rivalry among the producers and distributors. Only one dealer uses a pasteurizer and he is the only distributor who purchases milk outside an 8-mile radius.

Springfield v. Worcester.

It costs the Springfield dealers studied 16 per cent. more than Worcester dealers to distribute retail milk; and 25 per cent. more than the average of all dealers investigated. Except in the amount spent for maintenance, all the costs of distribution are lower in Worcester than in Springfield. As a matter of fact, differences in depreciation, maintenance and overhead are negligible. The labor item alone requires attention. Worcester has cheaper labor because a large proportion of the distributors are producers, and farm labor at $50 a month (cost of board included) is much lower than labor in the city. In addition to this, a fair proportion of Worcester's milk supply is distributed by foreign-born dealers who value their services cheaply.

A short time ago an ordinance was passed doing away with basement dairies in Springfield. This has been productive of much good, although it entails considerable expense. Depreciation has naturally increased in this city but without a corresponding increase in maintenance.

TABLE XI. — *A Detailed Comparative Study of Distribution Costs of Four Producing Distributors and Five Dealers.*

(A) PRODUCERS.

Investment.

PRODUCER'S NUMBER.	HORSES.		Milk Shed.	Ice House.	Stable.	Boiler.	Filler.	Ice Chest.	Harness.	Wagons.	Boxes.	Cans.	Total.
	Number.	Value.											
9, ...	3	$900 00	-	-	-	$150 00	$10 00	$100 00	$75 00	$350 00	$25 00	$8 00	$1,618 00
12, ...	3	800 00	$500 00	$300 00	$1,000 00	100 00	30 00	-	150 00	610 00	62 50	62 50	3,615 00
18, ...	3	800 00	100 00	200 00	-	275 00	72 00	-	70 00	650 00	37 50	-	2,204 50
23, ...	1	150 00	20 00	100 00	-	225 00	40 00	-	18 00	251 00	15 50	17 00	836 50
Total, . .	10	$2,650 00	$620 00	$600 00	$1,000 00	$750 00	$152 00	$100 00	$313 00	$1,861 00	$140 50	$87 50	$8,274 00

Depreciation.

9, ...	3	$60 00	-	-	-	$15 00	$2 00	$10 00	$25 00	$37 38	$5 00	$2 00	$156 38
12, ...	3	71 43	$15 00	$9 00	$30 00	10 00	3 50	-	30 00	75 38	7 82	-	252 13
18, ...	3	100 00	3 00	6 00	-	27 50	7 20	-	14 00	60 00	4 69	-	222 39
23, ...	1	50 00	60	3 00	-	15 00	4 00	-	3 60	24 23	3 10	3 40	106 93
Total, . .	10	$281 43	$18 60	$18 00	$30 00	$67 50	$16 70	$10 00	$72 60	$196 99	$20 61	$5 40	$737 83

Table XI. — *A Detailed Comparative Study of Distribution Costs of Four Producing Distributors and Five Dealers* — Con.

(A) Producers — *Concluded.*

Maintenance.

Producer's Number.	Repairs.	Sundries.	Shoeing.	Feed.	Bottles.	Cans.	Total.
9,	$95 00	$31 50	$72 00	$540 00	$48 00	$2 23	$788 73
12,	125 00	29 45	54 00	540 00	50 00	12 50	810 95
18,	80 00	22 75	72 00	352 56	234 00	-	761 31
23,	50 00	19 81	24 00	156 00	35 00	-	284 81
Total,	$350 00	$103 51	$222 00	$1,588 56	$367 00	$14 73	$2,645 80

Circulating Capital.

Producer's Number.	Rent.	Soap.	Caps.	Ice.	Light.	Fuel.	Stationery.	Insurance and Taxes.	Interest.	Surplus and Shrinkage.	Bad Bills.	Sundries.	Total.
9,	$144 00	$10 20	$13 50	$140 00	$6 60	$48 00	$6 00	$0 50	$76 40	-	$30 00	$27 00	$502 20
12,	-	15 00	15 00	50 00	23 00	50 00	20 00	98 50	182 75	-	25 00	54 00	533 25
18,	78 00	10 00	27 38	80 00	6 75	50 00	10 00	10 50	-	-	50 00	30 00	352 63
23,	24 00	6 00	16 00	70 00	12 00	-	10 00	4 50	28 32	-	10 00	25 00	205 82
Total,	$246 00	$41 20	$71 88	$340 00	$48 35	$148 00	$46 00	$114 00	$287 47	-	$115 00	$136 00	$1,593 90

Labor.

PRODUCER'S NUMBER.	Total.
9,	$1,790 20
12,	2,536 85
18,	1,578 63
23,	$842 90
Total,	$6,748 58

Grand Total.

Producers: —		
Depreciation,	$737 83	
Maintenance,	2,645 80	
Circulating capital,	1,593 90	
Labor,	6,748 58	
		$11,726 11

TABLE XI. — *A Detailed Comparative Study of Distribution Costs of Four Producing Distributors and Five Dealers* — Con.

(B) DEALERS.

Investment.

DEALER'S NUMBER.	HORSES.		Milk Shed.	Ice House.	Stable.	Boiler.	Washer.	Filler.	Pasteurizer.	Ice Chest.	Harness.	Wagons.	Boxes.	Cans.	Office.	Total.
	Number.	Value.														
13, ...	4	$1,100 00	-	-	-	$150 00	$15 00	$45 00	$40 00	$70 00	$140 00	$815 00	$50 00	-	-	$2,425 00
14, ...	3	900 00	$700 00	$300 00	$2,000 00	225 00	85 00	200 00	-	-	150 00	855 00	118 75	$85 00	$50 00	5,668 75
24, ...	12	3,300 00	5,000 00	2,000 00	2,000 00	400 00	1,000 00	200 00	-	-	800 00	4,115 00	525 00	400 00	-	19,740 00
26, ...	4	900 00	-	50 00	-	178 27	35 00	161 00	800 00	-	250 00	860 00	80 00	80 00	-	3,394 27
28, ...	5	1,375 00	-	-	-	450 00	-	50 00	-	100 00	235 00	1,135 00	68 75	48 00	-	3,461 75
Total, . .	28	$7,575 00	$5,700 00	$2,350 00	$4,000 00	$1,403 27	$1,135 00	$656 00	$840 00	$170 00	$1,575 00	$7,780 00	$842 50	$613 00	$50 00	$34,689 77

Depreciation.

13, ...	4	$115 68	-	-	-	$15 00	$6 00	-	$4 00	$7 00	$28 00	$77 34	$10 00	-	-	$263 02
14, ...	3	66 67	$21 00	$9 00	$60 00	22 50	8 50	$20 00	-	-	30 00	124 50	14 85	-	$5 00	382 02
24, ...	12	360 00	150 00	200 00	60 00	26 67	100 00	20 00	-	-	160 00	602 17	131 25	-	-	1,810 09
26, ...	4	76 92	-	1 50	-	17 82	2 33	10 73	53 33	-	42 50	54 66	16 00	$20 00	-	295 79
28, ...	5	125 00	-	-	-	45 00	-	10 00	-	10 00	58 75	140 63	13 75	-	-	403 13
Total, . .	28	$744 27	$171 00	$210 50	$120 00	$126 99	$116 83	$60 73	$57 33	$17 00	$319 25	$999 30	$185 85	$20 00	$5 00	$3,154 05

Maintenance.

Dealer's Number.	Repairs.	Sundries.	Shoeing.	Feed.	Bottles.	Cans.	Total.
13,	$90 00	$79 10	$72 00	$547 50	$75 00	-	$863 60
14,	178 00	68 63	72 00	1,095 00	156 25	$8 50	1,578 38
24,	764 00	158 75	360 00	810 94	700 00	160 00	2,953 69
26,	225 56	50 56	48 00	313 42	100 00	-	737 54
28,	256 00	95 50	120 00	1,200 00	300 00	10 67	1,982 17
Total,	$1,513 56	$452 54	$672 00	$3,966 86	$1,331 25	$179 17	$8,115 38

Circulating Capital.

Dealer's Number.	Rent.	Soap.	Caps.	Ice.	Light.	Fuel.	Stationery.	Insurance and Taxes.	Interest.	Surplus and Shrinkage.	Bad Bills.	Sundries.	Total.
13,	$180 00	$13 50	$32 85	$196 00	$21 00	$50 00	$50 00	$5 50	$121 25	$2 25	$100 00	$37 00	$809 35
14,	-	32 00	80 00	200 00	33 15	56 25	75 00	154 50	283 44	-	25 00	33 36	972 70
24,	-	216 00	136 88	100 00	172 00	365 00	400 00	605 11	987 00	-	1,478 02	135 00	4,595 01
26,	246 00	40 00	45 00	212 50	20 40	66 00	45 45	88 50	169 71	36 50	50 00	33 60	1,053 66
28,	180 00	18 00	51 00	375 00	33 00	100 00	30 00	45 50	173 08	200 00	150 00	44 20	1,399 78
Total,	$606 00	$319 50	$345 73	$1,083 50	$279 55	$637 25	$600 45	$899 11	$1,734 48	$238 75	$1,803 02	$283 16	$8,830 50

TABLE XI. — *A Detailed Comparative Study of Distribution Costs of Four Producing Distributors and Five Dealers* — Con.

(B) DEALERS — *Concluded.*

Labor.

DEALER'S NUMBER.	Total.	DEALER'S NUMBER.	Total.
13,	$2,706 00	26,	$2,745 70
14,	3,822 50	28,	4,467 76
24,	9,606 91	Total,	$23,318 87

Grand Total.

Dealers: —		
Depreciation,	$3,154 05	
Maintenance,	8,115 38	
Circulating capital,	8,830 50	
Labor,	23,348 87	
		$43,448 80

(C) SUMMARIES.

Producers.

PRODUCER'S NUMBER.	Depreciation.	Maintenance.	Circulating Capital.	Labor.	Total Cost.	Wagons.	QUARTS MILK DISTRIBUTED.			Quarts Cream Yearly.
							RETAIL MILK.		Wholesale.	
							Daily.	Yearly.		
9,	$156 38	$788 73	$502 20	$1,790 20	$3,237 51	2	440	160,600	29,200	-
12,	252 13	810 95	533 25	2,536 85	4,132 68	2	450	164,250	87,600	-
18,	222 39	761 31	352 63	1,578 63	2,914 96	1	400	146,000	-	-
23,	106 93	284 81	205 82	842 90	1,440 46	1	230	83,950	6,205	-
Total or average,	$737 83	$2,645 80	$1,593 90	$6,748 58	$11,725 61	6	1,520	554,800	123,005	-

PRODUCER'S NUMBER.	YEARLY COST.		QUARTS DISTRIBUTED PER —			MILES TRAVELED PER —		Cost per Mile.	CUSTOMERS SERVED.	
	Retail.	Per Quart.	Horse.	Mile.	Customer.	Day.	Customer.		Wholesale.	Retail.
9,	$3,091 57	$0 0192	146.66	29.3	1.189	15	.040	$0 56	4	370
12,	3,694 68	0251	150.00	18.8	1.000	24	.053	42	15	450
18,	2,914 96	0199	133 33	18.1	1.230	22	.067	36	-	325
23,	1,404 44	0167	230.00	15.3	1.150	15	.074	26	1	200
Total or average,	$11,105 65	$0 0200	152.00	20.0	1.130	76	.056	$0 40	20	1,345

TABLE XI. — *A Detailed Comparative Study of Distribution Costs of Four Producing Distributors and Five Dealers* — Con.

C. SUMMARIES — *Concluded.*

Dealers.

DEALER'S NUMBER.	Depreciation.	Maintenance.	Circulating Capital.	Labor.	Total Cost.	Wagons.	QUARTS MILK DISTRIBUTED.			Quarts Cream Yearly.
							RETAIL MILK.		Wholesale.	
							Daily.	Yearly.		
13,	$263 02	$863 60	$809 35	$2,706 00	$4,641 97	3	425	155,125	-	2,190
14,	382 02	1,578 38	972 70	3,822 50	6,755 60	3	1,100	401,500	182,500	-
24,	1,810 09	2,953 69	4,595 01	9,606 91	18,965 70	7	2,080	759,200	379,600	-
26,	295 79	737 54	1,053 66	2,745 70	4,832 69	3	650	237,250	102,200	-
28,	403 13	1,982 17	1,399 78	4,467 76	8,252 84	3	800	292,000	43,800	2,920
Total or average,	$3,154 05	$8,115 38	$8,830 50	$23,348 87	$43,448 80	19	5,055	1,845,075	708,100	5,110

DEALER'S NUMBER.	YEARLY COST.		QUARTS DISTRIBUTED PER —			MILES TRAVELED PER —		Cost per Mile.	CUSTOMERS SERVED.	
	Retail.	Per Quart.	Horse.	Mile.	Customer.	Day.	Customer.		Wholesale.	Retail.
13,	$4,574 27	$0 0295	106.25	23.6	1.416	18	.060	$0 70	-	300
14,	5,843 10	0145	366.66	45.8	1.100	24	.024	66	25	1,000
24,	17,067 70	0225	173.33	59.4	1.094	35	.018	1 50	60	1,900
26,	4,324 69	0182	162.50	50.0	1.083	13	.021	91	10	600
28,	7,931 64	0272	160.00	26.6	1.230	30	.046	76	8	650
Total or average,	$39,741 40	$0 0216	180.50	42.1	1.111	120	.027	$0 91	103	4,450

The Producer as a Distributor in Comparison with the Dealer.

Any comparison of costs that fails to recognize the difference between the business of the producer who distributes his own milk, or his own milk plus some purchased from his neighbors, and the dealer who buys all the milk he distributes, is surely inadequate. The data in Tables XI and XII are inserted to exhibit this comparison in some detail. The records of four producers and five distributors whose cost accounts were kept with unusual care are chosen for this comparison. As usual the figures on cost per quart (Table XI) are based on milk sold at retail. From the total cost of doing business 3 cents per quart were deducted for retail cream sold and one-half cent per quart for milk delivered at wholesale.

The most striking reflection in the whole comparison is the great difference in costs as between individuals whether producers or dealers. Producers' retailing costs run from 2.51 to 1.67 cents per quart, and dealers' from 2.95 cents to less than half that much, or 1.45 cents per quart. Such wide variations between individuals indicate the fruitlessness of drawing any but the most general conclusions from the final averages. It is evident that much remains to be done in the study of economical and efficient methods of distribution and in profitable investment in equipment and buildings.

1. According to these figures, the average producer is able to distribute retail milk more cheaply, it costing him 2 cents per quart against 2.16 cents for the dealer. An analysis of the figures, however, shows that the dealer's investment is about 12 per cent. greater than the producer's per 1,000 quarts of milk handled. There is some difference in maintenance, but on the whole this is in favor of the dealer.

2. The labor bill of the average dealer is noticeably greater per quart, notwithstanding he is near his market and saves in time. This is indicated by the fact that the dealer retails 42 quarts per mile to the producer's 20 — more than double. The dealer almost always has the advantage of shorter delivery routes. The producer must often travel several miles from his farm before he reaches his first customer and retrace this distance after his load has been delivered. In this instance the producer averaged 12⅔ miles per wagon; the dealer, only 6 miles per wagon.

3. The producer has the advantage in depreciation and working capital. In other words, the dealer invests more in his equipment and buildings, naturally increasing the depreciation and circulating capital accounts. The items of shrinkage and bad bills are significant. These two items are the most important of the overhead costs of the dealers here noted. As a whole the overhead charges and current supplies, *i.e.*, the circulating capital, of the dealers per 1,000 quarts handled are more than 60 per cent. higher than those of the producers.

4. The dealer gives better service in pasteurizing and clarifying and his labor account is also somewhat reduced by use of better labor-saving devices for washing, filling, etc.

TABLE XII. — *Analysis of Costs of Three Individual Dealers and Two Producing Distributors, giving Total Costs and Cost per Thousand Quarts of All Milk and Cream sold daily.*

	Quarts sold daily.	COST PER QUART.		INVESTMENT.		DEPRECIATION.		CIRCULATING CAPITAL.		MAINTENANCE.		LABOR.		EXPENSE.	
		All Sales (Cents).	Retail Milk[1] (Cents).	Total.	Per 1,000 Quarts.	Total.	Per 1,000 Quarts.	Total.	Per 1,000 Quarts.	Total.	Per 1,000 Quarts.	Total.	Per 1,000 Quarts.	Total.	Per 1,000 Quarts.
Dealer: —															
No. 13,	430	2.95	2.95	$2,425	$5,640	$263	$612	$809	$1,876	$864	$2,009	$2,706	$6,293	$4,642	$10,790
No. 14,	1,600	1.15	1.45	5,669	3,543	382	239	973	608	1,578	986	3,823	2,389	6,756	4,222
No. 24,	3,120	1.66	2.24	19,740	6,327	1,810	580	4,595	1,472	2,954	947	9,607	3,079	18,966	6,078
Producer: —															
No. 12,	690	1.64	2.51	3,615	5,239	252	365	533	772	811	1,175	2,537	3,677	4,133	5,989
No. 23,	247	1.60	1.67	837	3,387	107	433	206	834	285	1,154	843	3,412	1,441	5,833

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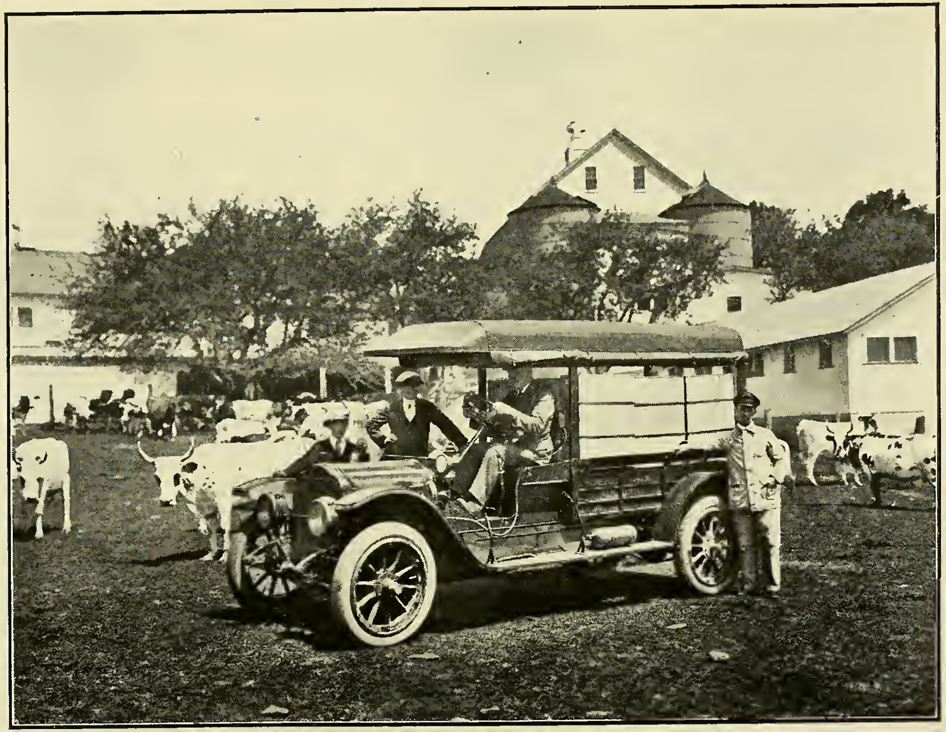
[1] Retail costs in this column obtained by deducting .5 cent per quart for wholesale milk delivery and 3 cents per quart for cream. All remaining costs are charged to retailing.



Motor truck equipment of a successful producing distributor.

One must bear in mind, however, that the expenses of collecting the milk are not charged to the dealer. The above figures are calculated from the time the milk arrives at the dairy or distributing plant until it reaches the consumer, the cost of transportation from the producer to the dealer's plant, including freight and haulage from producer to shipping point and from shipping destination to milk plant, not being included, whereas the producer's costs include haulage to the city. To this degree the figures are not comparable. The dealer sometimes collects from the producer, sometimes pays a higher price for milk delivered at his plant, sometimes pays freight charges. Usually the difference between milk collected by the dealer and milk delivered to the dealer is about one-half cent per quart.

When milk is shipped from a distance it is usually laid down at the dealer's plant for a price equal to or less than the local producing distributor can produce it. In such case the dealer and the producer who sells his own milk may both start from their doors with loads of milk equal in value. When the dealer procures local milk he usually pays one-half cent per quart more for it if brought to his dairy.

Further analysis, both from a collective and an individual standpoint, indicates that the variation in the cost of distribution is related closely to the number of quarts delivered per horse in conjunction with the quarts delivered per mile. One dealer (No. 14) with three horses delivers 1,600 quarts daily (including 500 quarts of wholesale milk in cans). Although his mileage per horse (8 miles) is higher than most of the dealers, his exceptionally heavy delivery, 45.8 quarts per mile, helps to bring his retail cost down to 1.45 cents per quart. Of the producers, No. 23 delivers at less cost than others in the group, although his mileage is 15 per horse; this is accounted for by the large load hauled — 230 retail quarts per horse — and his comparatively small overhead charges. Producer No. 9 carries 520 quarts on two wagons. His horse load is good and his delivery per mile (29.3 quarts), retail and wholesale, is larger than any other producer in the group — in fact, nearly 50 per cent. above the average.

Table XII will repay careful study. The analysis of cost per 1,000 quarts of milk delivered daily is excellent for comparative study and reveals very striking individual variations. No. 13, who uses four horses and travels 18 miles, with an average load of 107 quarts per horse to deliver 430 quarts daily, has high cost items in all respects. His labor and working capital accounts are nearly thrice those of No. 14 and his other items twice as great. Dealer No. 24 makes up for his high investment and large depreciation and overhead costs by a low maintenance expense and a small labor bill. His labor charge is only one-half that of No. 13, and $700 less per 1,000 quarts than that of the average producer.

The efficiency of No. 14 has been noted above. His economies extend to every division of his business. His labor bill is extremely small and except for horse feed his maintenance costs are very low.

TABLE XIII. — *Cost of Distribution of Special Milk.*

Summary Statement (Two Plants).

DEALER.	Investment.	Depreciation.	Maintenance.	Circulating Capital.	LABOR.		Total Cost.	RETAIL DISTRIBUTION.	
					Preparation.	Delivery.		Daily.	Yearly.
No. 1, ...	$5,985[1]	$759 50	$1,833 29	$1,798 28	$383 25	$1,035 69	$5,810 01	350	127,750
No. 2, ...	–[2]	85 00	282 18	604 16	138 00	876 00	1,985 34	102	37,200

DEALER.	Cost per Quart (Cents).	Miles Daily.	Cost per Mile (Cents).	Quarts per Mile.	Quarts per Customer.	Miles per Customer.	Customers per Mile.	Total Customers.	Selling Price (Cents).
No. 1, ...	4.54	47[3]	23.76[4]	7.45	1.27	.171	5.8	275	12
No. 2, ...	5.34	15	36.00	6.80	.70	.103	9.7	145	12

Cost per 1,000 Quarts Distributed Yearly.

DEALER.	Depreciation per 1,000 Quarts.	Maintenance per 1,000 Quarts.	Circulating Capital per 1,000 Quarts.	Labor per 1,000 Quarts.	Total per 1,000 Quarts.
No. 1, ...	$5 94	$14 35	$14 08	$11 11	$45 48
No. 2, ...	2 63	8 74	18 72	31 42	61 51

---

[1] Including $2,770 for Ford car and White motor truck.

[2] Rents buildings, uses horses, wagons, etc., for other purposes.

[3] Including collection, 67.

[4] Including collection.

Cost of Delivery of Special Milk.

Fortunately reliable data were secured from four distributors who had kept accurate accounts for a number of years. Two of these produced and distributed what they termed "special" milk — unpasteurized, but held to be equal in purity and cleanliness to certified milk. The term "special" is very unsatisfactory. There is no standard for such milk. Whether the term means anything depends on the producer and seller. Frequently the milk is of excellent quality. In these instances it is sold to the consumer at 12 cents per quart. This "special" milk entails extra care, extra labor and good equipment and requires a special market; moreover, the distributors must of necessity travel far to dispose of their product. Distributor No. 1 traversed 47 miles daily to dispose of 350 quarts — but 7.45 quarts per mile traveled. In case No. 2, 15 miles were traveled daily to dispose of 83 quarts of "special" milk, 19 quarts of skimmed milk, and 4.9 quarts of cream; disregarding the skimmed milk, this is equal to 5.86 quarts of "special" milk and cream per mile traveled.

No. 1 has much higher depreciation and maintenance expense than No. 2, due to the use of a Ford car and White motor truck. The extra cost, however, is offset by the reduced cost of labor, which is but a trifle more than a third that of No. 2 ($11.11 as against $31.42 per 1,000 quarts). At least twelve hours of labor were saved daily at 15 cents per hour. As in the case of distributors of market milk, the same conclusion can be drawn from the above figures, namely, economic distribution depends on the number of quarts per horse, in conjunction with the quarts per mile.

Cost of Collection and Distribution of Wholesale Milk in Cans.

These figures demonstrate the reasonableness of calculating one-half cent per quart for the cost of delivering wholesale milk, as we have done in the case of mixed delivery in the figures given in the previous pages. In this plant the cost was a little more than three-fourths of a cent per quart including collection from producers. Two hours daily were occupied by a man and two horses for collecting and six hours for delivery. It is contended, however, that the motor truck is more economical for wholesale delivery, provided the truck can be kept fully occupied and the location will permit its use during the winter.

TABLE XIV.

	Investment.	Depreciation.	Maintenance.
Buildings,	$1,280	$38 40	$70 50
Equipment,	597	62 50	–
Horses,	600	65 00	258 37
Totals,	$2,477	$165 90	$328 87

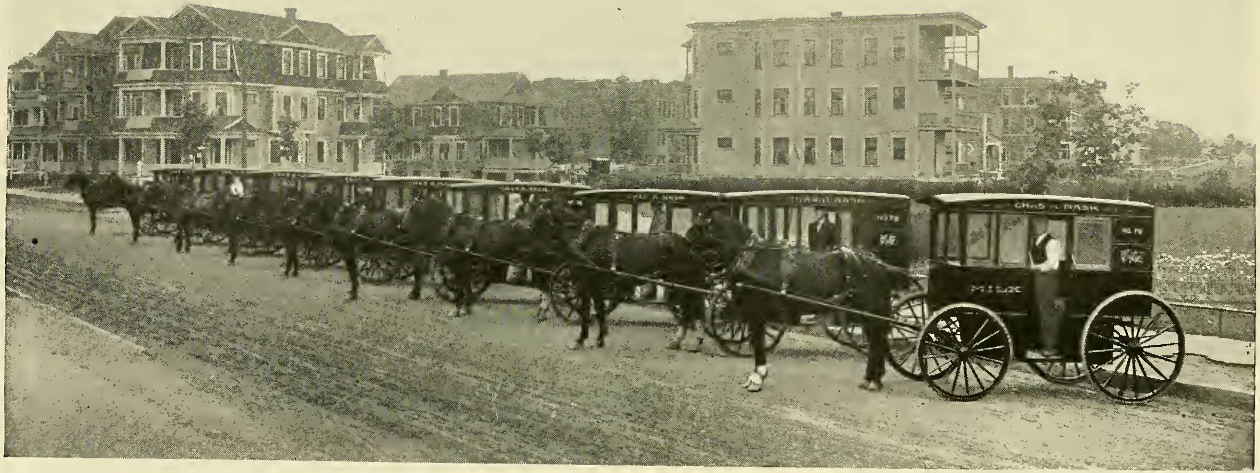
Circulating capital: —	
Ice,	$100 00
Interest,	123 85
Shrinkage,	86 68
Other,	91 20
Total,	$401 73
Labor,	$803 00
Total costs,	$1,699.50
Milk handled: —	
Daily (quarts),	6000
Yearly (quarts),	219,000
Cost per quart (cents),	.78
Cost per mile (cents),	24.00
Mileage —	
Collection,	4
Delivery,	15
Customers,	12
Quarts per customer,	50
Miles per customer,	1.58
Quarts per mile,	31.60
Quarts per horse,	300

Motor Truck Delivery.

The actual cost figures of motor truck milk delivery are of interest in view of the increasing prevalence of these vehicles. Notice that the per mile cost for horse delivery as given above is 24 cents based on about 7,000 miles traveled yearly. The costs below are based on 10,000 miles annually. Under ordinary conditions the truck equipment would deliver the milk on the above route in four hours, one-half the time taken by horses.

The operating cost of a motor truck suitable for distribution of wholesale milk or of "special milk," where the haul is long or loads are heavy, is given below. These figures apply to a White motor truck, three-quarters to 1 ton, in actual operation (1915) by a producing distributor of milk.

	Per Mile.
Gasoline,	$0.0100
Oil,	.0016
Grease, waste, etc.,	.0010
Running expenses,	.0050
Tires, total cost per set, $175; guaranteed mileage, 5,000,	.0350
Overhauling and painting after 20,000 miles, approximately $350,	.0175
Interest 5 per cent, depreciation 20 per cent, on an investment of $2,250 =$562.50 on approximate yearly mileage of 10,000,	.0562
Insurance (fire 1⅞ per cent., collision 2⅝ per cent.) on $2,250 = $96.18 on mileage of 10,000,	.0096
Driver, $850 per year, over mileage of 10,000,	.0850
Total cost per mile,	$0.2209



The retail delivery equipment of one dealer.

Cost of Distribution of Cream.

The distribution of cream exclusively is analogous to the distribution of "special" or of certified milk, excepting that the cost of delivery is increased because the overhead charges are high in comparison with the quantity delivered. Cream from dealers who delivered a small quantity of cream to their regular milk customers is not subject to this high overhead charge and need not be considered here. Only one plant delivering cream exclusively is included in this study. A summarized statement of its expenses is presented below. These figures take no account of bottles which were paid for by the customers. Notwithstanding this fact, the long route and small daily delivery raises the cost to more than 7.5 cents ($0.0759) per quart, as against 4.5 and 6.1 cents for retailing "special" milk.

Summary of Costs of delivering Cream (One Plant).

Depreciation,	$112 23
Maintenance,	543 25
Circulating capital,	399 10
Labor,	1,155 90
Total yearly cost,	$2,210 48
Cost per 1,000 quarts yearly,	$75 91
Cream delivered yearly (quarts),	29,120
Cream delivered daily (six days a week) (quarts),	93.3
Customers,	95
Quarts per customer,	.98
Cost per quart to deliver,	$0.0759
Miles traveled,	18
Cost per mile,	$0.33
Quarts per mile,	5.18
Miles per customer,	.19
Customers per mile,	5.3

Significant Facts of Distribution showing Individual Variations.

Table XV is an attempt to exhibit the salient facts of milk delivery by individual milkmen. Amherst and Walpole distributors are not included; wholesale dealers and those using motor trucks, cream and skimmed-milk handlers and those who furnished imperfect data are also omitted.

TABLE XV. — *Grouping of Sixty-six Individual Distributors on Basis of Cost per Quart of retailing Milk showing Number of Quarts retailed, Quarts and Miles per Wagon Daily, Quarts retailed per Mile and Customers per Mile together with Total Daily Distribution, Wholesale and Retail.*

Group I.

NUMBER IN GROUP.	RETAIL COST, CENTS PER QUART.		Number of Routes.	QUARTS SOLD DAILY AT RETAIL.		Miles traveled per Wagon daily.	Quarts retailed per Mile per Wagon.	Customers per Mile.	Quarts per Day, Wholesale and Retail.
	Group.	Individual.		Total.	Per Wagon.				
4, ...	Under 1.5	1.05 1.21 1.21 1.45	2 1 2 3	460 545 500 1,100	230 545 250 367	10.0 8.0 10.0 8.0	23.0 68.0 25.0 45.8	19.5 68.7 10.0 41.7	700 620 715 1,600
Average, ...	-	-	-	651	326	9.0	38.7	29.7	908.7

Group II.

NUMBER IN GROUP.	RETAIL COST, CENTS PER QUART.		Number of Routes.	QUARTS SOLD DAILY AT RETAIL.		Miles traveled per Wagon daily.	Quarts retailed per Mile per Wagon.	Customers per Mile.	Quarts per Day, Wholesale and Retail.
	Group.	Individual.		Total.	Per Wagon.				
14, ...	1.5 to 2	1.61 1.63 1.64 1.67 1.67 1.82 1.85 1.86 1.89 1.92 1.93 1.94 1.96 1.99	5 1 2 1 2 3 2 2 1 2 1 2 1 2	1,200 450 560 230 650 650 622 550 280 440 200 400 428 400	240 450 280 239 325 217 311 275 280 220 200 200 428 200	8.0 12.0 4.0 15.0 14.0 4.3 7.5 7.0 5.0 7.5 7.0 12.0 20.0 11.0	30.0 37.5 70.0 15.3 23.2 50.0 41.5 39.3 56.0 29.3 28.6 16.7 21.4 18.1	29.4 58.3 47.5 13.3 17.9 46.1 33.3 33.8 34.0 24.6 22.8 16.7 19.0 14.8	1,550 550 720 247 750 939 662 750 312 520 215 500 445 400
Average, ...	-	-	-	504	261	8.8	29.6	26.6.	610.8

Group III.

16,	2 to 2.5	2.02	2	530	265	6.5	40.7	34.6	660
		2.04	2	500	250	15.0	16.6	16.7	668
		2.11	1	420	420	6.0	70.0	58.3	490
		2.12	1	308	308	12.0	25.7	21.7	340
		2.12	2	650	325	20.0	16.2	8.8	1,017
		2.18	1	214	214	10.0	21.4	18.5	214
		2.22	1	330	330	8.0	41.2	28.1	378
		2.25	4	850	213	5.5	38.6	31.4	1,050
		2.25	7	2,080	297	5.0	59.4	54.3	3,120
		2.32	3	700	233	9.0	25.9	20.6	1,400
		2.32	2	360	180	8.0	22.5	28.1	640
		2.37	2	552	276	5.0	55.2	45.0	992
		2.42	2	280	140	7.5	18.7	20.0	460
		2.45	2	300	150	5.0	30.0	20.0	502
		2.47	1	300	300	15.0	20.0	16.7	306
		2.47	1	225	225	22.0	10.2	9.0	239
Average,	-	-	-	537	253	8.6	29.5	25.1	780

Group IV.

13,	2.5 to 3	2.51	4	1,100	275	8.0	34.4	31.3	1,217
		2.51	2	450	225	12.0	18.8	18.8	690
		2.54	2	300	150	8.0	18.8	20.0	300
		2.57	2	464	232	15.0	15.5	12.7	500
		2.72	3	800	267	10.0	26.6	21.7	928
		2.78	1	175	175	12.0	14.5	12.5	257
		2.78	7	2,000	286	10.0	28.6	20.0	2,320
		2.79	2	320	160	5.0	32.0	20.0	320
		2.81	2	380	190	10.0	19.0	12.5	525
		2.86	5	1,400	280	10.0	28.0	24.2	1,654
		2.87	1	320	320	5.0	64.0	50.0	480
		2.95	2	425	213	9.0	23.6	16.7	431
		2.97	2	300	150	8.0	18.8	12.5	447
Average,	-	-	-	649	241	9.5	25.0	20.3	774.5

TABLE XV — *Grouping of Sixty-six Individual Distributors on Basis of Cost per Quart of retailing Milk showing Number of Quarts retailed, Quarts and Miles per Wagon Daily, Quarts retailed per Mile and Customers per Mile together with Total Daily Distribution, Wholesale and Retail* — Con.

Group V.

NUMBER IN GROUP.	RETAIL COST, CENTS PER QUART.		Number of Routes.	QUARTS SOLD DAILY AT RETAIL.		Miles traveled per Wagon daily.	Quarts retailed per Mile per Wagon.	Customers per Mile.	Quarts per Day, Wholesale and Retail.
	Group.	Individual.		Total.	Per Wagon.				
12,	3 to 3.5	3.01	2	300	150	10.0	15.0	12.0	675
		3.02	1	216	216	4.0	54.0	37.5	376
		3.06	2	450	225	4.0	56.3	62.5	834
		3.11	1	240	240	5.0	48.0	38.0	360
		3.12	1	268	268	10.0	26.8	16.2	324
		3.19	1	260	260	10.0	26.0	26.0	300
		3.21	4	1,080	270	6.5	41.5	30.8	1,315
		3.23	3	650	217	4.0	54.2	50.0	810
		3.26	2	440	220	15.0	14.6	10.6	451
		3.35	1	97	97	12.0	8.0	2.8	218
		3.38	11	3,146	286	8.0	35.7	39.8	3,392
		3.50	2	290	145	7.5	19.3	16.7	353
Average,	-	-	-	620	240	7.7	30.9	29.2	784

Group VI.

7,	Over 3.5	3.66	3	1,065	355	6.0	59.1	38.9	1,065
		3.68	1	150	150	15.0	10.0	8.0	152
		3.82	1	370	370	12.0	30.8	16.7	374
		4.47	1	186	186	6.0	31.0	41.6	306
		4.70	2	175	88	4.0	22.0	18.7	289
		5.34	1	102	102	15.0	6.8	9.7	107
		5.57	1	175	175	15.0	11.6	9.3	295
Average,	-	-	-	318	222	9.0	25.0	19.0	370

The per quart costs of retail delivery of the 66 distributors considered are approximately as follows: —

4, or 6 per cent., less than 1.5 cents.
14, or 21 per cent., between 1.5 and 2 cents.
16, or 24 per cent., between 2 and 2.5 cents.
13, or 20 per cent., between 2.5 and 3 cents.
12, or 18 per cent., between 3 and 3.5 cents.
7, or 11 per cent., over 3.5 cents.

The first striking observation is the wide variation in costs, and the comparatively uniform distribution between 1.5 and 3.5 cents.

The second is the fact that there is no marked correlation between costs and size of business; dealers distributing 300 quarts or less and dealers distributing more than 1,000 quarts daily are found in every group except the first. The third group contains as many dealers handling less than 500 quarts daily as any group and more dealers handling more than 1,000 quarts daily than any other group.

Third, considered by groups, the cost per quart of retailing increases and the size of the retail load decreases from the first to the sixth group. It should be noted that the high average retail load of the first group is due to one dealer whose load was exceptionally heavy.

Fourth, some correlation is discernible between the number of quarts retailed per mile of haul and the cost per quart, the more quarts per mile the less the cost; but the correlation is not consistent. The average delivery for Group III is 29.5 quarts per mile; that of Group V is 30.9 quarts per mile, though the average cost per quart of delivery of the latter is about 50 per cent. higher than the former. These two factors, however — the size of the load and the density of delivery (quarts per mile) — are two very important considerations in milk delivery.

Fifth, the individual variations in the number of quarts retailed per mile per wagon, within the groups, are very significant. In Group I, for example, one dealer distributes 23 and another 68 quarts per mile. In Group II the variations run from 15 to 70; in Group III, from 10 to 70, and in Group V, from 8 to 56 quarts per mile. Under these conditions it is very evident that the costs of milk delivery must vary tremendously.

Finally, the cost of delivery is closely related to the miles traveled per customer (or, inversely, the number of customers per mile), running from one-thirtieth of a mile between deliveries in the first group to one-nineteenth of a mile in the sixth group. Nothing more strikingly indicates the individual differences in delivery conditions than the customers served per mile traveled. The first group contains one dealer with a record of 68 customers and another with only 10 customers a mile. The third group shows variations between 9 and nearly 60 customers. Group V has one dealer who serves 62 customers a mile, and another who serves less than 3. The significance of these relationships will be considered under "Disadvantages of Competitive Distribution."

Some Obvious Disadvantages in Competitive Distribution of Milk.

The investigation clearly indicates the very wide diversity of costs in the retailing of milk. At the same time the milk-retailing service under competitive conditions is fairly satisfactory. The consumer usually gets his milk on time and in such quantities as he requires. If the quality of milk delivered by one dealer is not satisfactory, several others are available. It is questionable, however, whether the consumer does not pay roundly for this competitive service. Several economic disadvantages may be indicated.

1. *Overcapitalization.* — The great majority of the plants visited are of one or two wagon capacity. Eighty-four per cent. of them deliver 1,000 quarts or less daily; 59 per cent., 500 quarts or less; and 23 per cent., 300 or less. To meet the demands of his customers, comply with the milk regulations and compete with other milkmen the progressive dealer installs machinery for washing, filling and capping bottles, clarifying, pasteurizing and cooling his milk.

One recognizes that milk is highly perishable and that the time for the processing is necessarily short. Some dealers, however, have installed pasteurizers capable of disposing of 400 gallons per hour, although their total quantity handled is but 900 quarts per day. Some have bottle-fillers filling 12 bottles at once when handling only 350 bottles daily. This means running the plant below its capacity. A few dealers have buildings or horses and wagons much more ample and expensive than necessary. In some instances the total investment runs to 1.5 cents ($0.015) a quart sold yearly, whereas the average investment for that size of business is less than one-half cent ($0.0043) a quart; in other instances the investment is 3.4 cents a quart when the average is less than 1 cent ($0.0095) per quart for plants of similar capacity.

2. *Small Daily Deliveries per Horse.* — A load for a good horse over a good road is 300 quarts of milk in bottles but the investigation disclosed the fact that the usual load is much less. The average load of 10 distributors in Springfield is 216 quarts per horse (307 per wagon), and of 28 Worcester milkmen, 234.4 quarts per horse (346.1 per wagon), including wholesale milk in cans. On the other hand, a rather large percentage of dealers haul 300 quarts or more per wagon. More than 12 per cent. of the milkmen retail 15 quarts or less per mile of travel in contrast to nearly 14 per cent. who average more than 55 quarts a mile. The average delivery is about 32 quarts per mile per wagon. That the size of load bears a direct relation to the cost of delivery is shown in Table XV.

3. *Long Hauls are usually Uneconomical.* — Several instances can be cited of distributors who traveled from 10 to 15 miles to retail from 100 to 200 quarts of milk. When the distributor is a long distance from his market or when the distance between stops is great, there is a considerable waste both in man and horse labor through lost time. This is somewhat offset by the drivers making their daily entries during these intervals.

More than 20 per cent. of the routes average 14 miles long and almost half of them average 13 miles.

4. *Loss of Bottles.* — In Worcester 30 dealers, delivering 15,809 quarts per day, claim a loss of $4,913.42 yearly in bottles. Most of the loss in bottles is the fault of consumers. Bottles are frequently unfit for service when returned and many dealers state that they destroy such bottles. Milk bottles are handy receptacles during preserving season, and one dealer told of a housewife who proudly exhibited 100 quart bottles filled with preserves and, to add insult to injury, asked him for a sufficient number of caps to cover them.

5. *Bad Debts.* — This waste is common to all businesses which extend credit but the competitive milk dealer suffers more than ordinary loss because unscrupulous persons have a variety of methods for evading the payment of small bills. To prevent this loss many dealers make special trips for collecting. Bad debts cost Springfield and Worcester about 2½ per cent. of all costs of distribution. These losses aggregate $0.54 per 1,000 quarts in Springfield and $0.82 per 1,000 quarts in Worcester. The loss depends entirely on the class of trade, however, and no comparisons or general conclusions should be drawn from these figures.

6. *Shrinkage.* — This loss, seemingly insignificant, amounts to a considerable sum in the course of a year. It cannot, however, be wholly charged to distribution, as a certain amount is lost in transportation through carelessness in transit and leaky and dented cans. A good filling apparatus reduces this loss to a minimum in the dairy and whatever loss may be sustained in transit is probably borne by the producer who ships in cans. In general the shipper receives payment for only 8 quarts per can, though the can usually contains 8¼ to 8½ quarts.

7. *Surplus and Spoilage.* — This item is considerable in all towns and cities visited and it is one of the great and ever-present problems which the dealer is trying to overcome. Three factors contribute to the problem of surplus milk: —

(*a*) Restaurants and lunch counters which close on Sunday.
(*b*) Decreased demand owing to depopulation of cities during summer.
(*c*) Excessive production of milk at certain seasons.

The solution of the first factor is the business of the dealer. But to solve the question of decreased consumption, which occurs regularly and covers a long period, and of overproduction during certain months of the year is really the business of the producer.

Closely allied to shrinkage and surplus is spoilage. Milk which cannot be delivered at once is very likely to sour and so become a total loss. Naturally this waste is more prevalent during the summer at the time of surplus production. The producer who delivers his own milk can sometimes regulate the supply by producing more winter milk, by feeding some milk to calves or pigs, or he may be able to sell it to a creamery. The small dealer can do little but dump the surplus into the sewer.

In the aggregate the question of surplus milk is a big one which many dealers, large and small, have wrestled with for years with little success. An emergency butter and cheese factory managed co-operatively, which will utilize part of the existing equipment and take care of all the extra milk, is, perhaps, the best suggestion. Some relief will come from a form of contract with the producers which provides for definite variations in supply. At best there will always be a loss at this point.

The loss sustained by 10 dealers in Springfield, delivering 9,600 quarts wholesale and retail daily, amounted to $1,661.50 per year, or 52 cents per 1,000 quarts retailed annually. This does not represent the whole value of the milk; it was disposed of at the above loss.

8. *Duplication in Routes.* — The economic waste through duplication of milk routes was evident in all the towns and cities visited. From personal observation, at an apartment house containing four families, three milkmen called to deliver 4 quarts of milk; at another fourth-floor tenement three different milkmen climb four flights every day to deliver 6 pints to four families. Between the hours of 3 A.M. and 7 A.M. 42 milk wagons were observed to pass down Bowdoin Street, Worcester; only one failed to deposit milk within a distance of 400 yards from the observer. Similar conditions were found in all the other towns and cities visited.

In Worcester 103 one-horse milk wagons and 62 two-horse wagons average approximately 8½ miles per wagon per day; the 64 Worcester retail routes considered in this study aggregate 565 miles, 8.83 miles per route. Eight and one-half miles is probably a conservative estimate for approximately 265 milk wagons distributing milk daily in Worcester. The total public street mileage within the city limits is 220, but several miles are practically unoccupied. These milk wagons cover approximately 2,250 miles daily to supply the houses on less than 220 miles of streets. Probably they travel 10 to 14 times the populated street mileage every day.

Duplication of delivery routes is common to all retail business, but in large cities measures have been taken to overcome this waste through central delivery agencies, where the parcels are assembled, sorted and delivered regularly. The system has proved economical but the objections to this method for the delivery of milk are too serious to overcome, except by the establishment of a co-operative milk plant.

9. Another economic waste generally overlooked, common to other commodities as well as milk, is shipping to other markets than the local one. Why should Worcester, the center of one of the finest dairying sections, draw on Maine for its milk supply, when milk produced in the vicinity of Worcester is shipped to Boston? Other things being equal, the local market is the best market. Long-distance shipments are expensive to some one, and cause shrinkage and deterioration in quality. The producer in Massachusetts is in the very favorable position of having his market at his very door, yet he frequently seeks one further afield at necessarily increased cost to the consumer or a smaller return to him.

SUGGESTIONS FOR IMPROVING CONDITIONS.

1. Keeping adequate accounts to show cost of operation and calling attention to wasteful methods and inefficiencies. A little study will show many leaks which can often very easily be stopped.

2. Standardizing distribution. The data indicate the need of determining what is adequate and efficient equipment for a 500, 800 or 1,200 quart delivery. Is a two-horse load with one driver and a helper or the one-man, one-horse unit the more economical? None of these things has been worked out.

To answer these questions completely means standardizing the milk-distributing business; the answer will indicate means of eliminating waste, lessening costs and increasing service. Many such studies as this must be made but even this first one indicates some points of attack. Not only should the individual distributor study his business, but organizations of distributors should be formed in each town and city for mutual improvement and the discussion of points of economy, and for agreement on some division of territory to lessen duplication of routes and to protect their mutual interests.

3. The introduction of the ticket system to lessen collection costs and save time in delivery. The investigation indicates that the use of tickets tends to eliminate loss of bottles and bad accounts.

4. Large daily deliveries per horse and per driver. Several progressive firms in cities not here considered give a bonus to the driver for all deliveries and collections, and a commission on all new business above a certain minimum. This makes it an object for the driver to increase his sales, stop at a few more doors, obtain new customers and climb additional stairs. Long hauls from farm to delivery district are costly and the longer the initial haul the more milk deliveries necessary in order that this high initial cost may be offset.

5. Co-operative delivery. But, after all is said, the final adequate solution of milk distribution will come only through municipal delivery or the organization of producing distributors. In small cities and towns a co-operative milk plant, owned and managed by dairymen, is very feasible. One plant could easily process and deliver the necessary 2,500 to 10,000 quarts per day and solve most if not all of the problems of economical and adequate supply.

6. Central milk plants. The problem of milk distribution in large cities is difficult but the organization of the small milkmen operating in one section of a city into a distributing agency would cure many ills and bring about cheaper delivery. Organization of selling is an old matter to manufacturers and merchandisers but not to dairymen. The difficulties are personal, but sometimes personal jealousies and suspicions are fatal to progress and profits.

The solution of the milk problem is in the hands of the milk producers and dealers. If they have sufficient courage, foresight, perseverance and determination to organize for the study of their own business and the efficient disposal of their own product, all concerned will benefit.

The dairymen supplying a large percentage of the milk of Erie, Pa., have owned and operated their own plant for years. They handle milk, cream and ice cream and not only distribute an excellent quality of milk at low cost, but turn over to the producer a much larger percentage of the consumer's price than he ordinarily obtains. Their success commends their methods to the attention of progressive distributors.

They point to the following achievements: (1) a pure milk supply with an amazingly low bacterial count; (2) a lower price than in many other cities; (3) elimination of duplicate routes, resulting in (4) large deliveries per horse and driver; (5) concentration in large and convenient plants; (6) economical disposal of surplus milk by means of a condensery which the association operates; (7) better wages to employees and (8) satisfactory prices to the producers; (9) practical elimination of the difficulties which usually arise between producer and dealer; (10) no wasteful competition and (11) not a cent paid either in interest or dividends to the original shareholders; (12) every cent of net receipts has gone to the producers, to the plant or to a reserve fund.

Not only this, but this method places the distribution on such a basis that the town authorities could supervise the supply at a minimum cost by co-operating with other towns similarly situated. The cost of upkeep of a laboratory for a chemist and inspector in a small town is prohibitive at present, but if borne jointly by several towns the expense would be reduced to a figure well within their means. The advantages obtained by milk inspection are too well known to need consideration here.

BULLETIN No. 174.

DEPARTMENT OF CHEMISTRY.

THE COMPOSITION, DIGESTIBILITY AND FEEDING VALUE OF PUMPKINS.

BY J. B. LINDSEY.

SUMMARY OF THE RESULTS.

1. The pumpkin contains some 17 per cent. of shell, 73 per cent. of flesh, and 9 to 10 per cent. of seed and connecting tissue. It is a watery fruit, showing extremes of 84 to 91 per cent., with an average of 88 per cent.

2. The whole pumpkin is relatively rich in ash; the seed shows noticeably less ash than the remainder of the fruit.

On the basis of dry matter, the entire pumpkin contains rather more total protein than is found in grains and roots. It also contains some 18 per cent. of total sugars, of which one-third was found to be present in the form of cane sugar. The fruit minus the seeds contains nearly 43 per cent. of total sugars, which explains in a measure its desirability as a human food. The pumpkin seeds are very rich in fat, and are composed substantially of one-third fat, one-third protein and one-fifth fiber, the balance being carbohydrates and ash.

3. A number of digestion trials were made with sheep, and showed the pumpkin to be about 81 per cent. digestible. On substantially the same water basis, and allowing for the increased food value of the fat, the pumpkin appears to have about 20 per cent. greater feeding value than mangels and turnips.

4. Feeding experiments were made with dairy cows, substituting in the ration 30 pounds of cut pumpkins for 5 pounds of hay. The results secured indicated that 5 to 6 pounds of pumpkins were equal in food value to 1 pound of hay. The Vermont station concluded that 2½ pounds of pumpkins were about equal to 1 pound of silage, and that 6½ pounds were fully equal to 1 pound of hay. On page 66 will be found the conclusions of other investigators.

The pumpkin had a tendency to increase temporarily the fat percentage in the milk, due evidently to the oil contained in the seed.

5. The seeds appeared to be free from any injurious effects upon the animals when fed in the amounts found in the entire fruit, contrary to the notion prevalent among many farmers. In foreign countries they are often dried and ground, and serve as a very nutritious and harmless food, if not fed in too large amounts.

6. It is not considered good economy to grow pumpkins exclusively as a food for either cows or pigs, because of their high water content and poor keeping quality. For the latter reason it is advisable to feed them in the late fall or early winter. In one instance a yield of 9 tons is reported when they were grown exclusively, on which basis they would yield about 2,000 pounds of actual food material (digestible organic matter plus fat multiplied by 2.2) as against 3,000 pounds derived from corn. Their place in the farm economy seems in a way to have been discovered by the farmer, namely, in their limited cultivation together with corn.

7. They may be fed cut reasonably fine at the rate of 30 to possibly 50 pounds per head daily, in place of 6 to 10 pounds of hay, in addition to hay and a reasonable amount of grain. It is not advised to feed them with other watery foods such as roots and silage.

They also may be fed (cut fine) to pigs, mixed with a combination of equal parts, by weight, of corn meal and fine wheat middlings, or with a mixture, by weight, of 95 parts corn meal and 5 parts of digester tankage. It is doubtful if it pays to cook them. If fed in too large amounts daily they furnish too much bulk but insufficient nutriment, and as a result the animals are likely to lose in flesh.

COMPOSITION OF THE PUMPKIN.

The ordinary field pumpkin (*Cucurbita pepo*) is planted more or less by New England farmers, frequently in the field with corn. It is used as a human food, particularly for pies, and is also fed to pigs and to dairy and beef cattle.

Ulbricht and Kosutany[1] have shown that in twelve different varieties of the genus *Cucurbita* the parts were present in the following proportions: —

	Per cent.
Shell,	17
Flesh,	73
Seed,	2
Seed and supporting tissue,	7

The pumpkin is a watery fruit. We have found variations of from 84.08 to 91.18 per cent., with an average of 87.53 per cent. in four lots grown on two farms in two different years. In the pumpkin minus the seeds and connecting tissue variations of from 90 to 94 per cent. were noted, with an average of 92.78 per cent., while the seeds contained from 43 to 47 per cent. The seeds, it will be noted, were much less watery than the other portions of the fruit. It was noted that the ripe pumpkins without the seeds contained 4 per cent. less water than the same material less mature. The riper the fruit and the drier the autumn the higher will be the percentage of dry matter.

Other investigators, including Dahlin,[2] Braconnet,[2] Zeunak,[2] Gerardin,[2] Wanderleben,[2] found in 10 sorts of the entire fruit extremes of from 85.8 to 94.2 per cent. of water, with an average of 90 per cent. Storer and Lewis,[2] with 5 varieties, noted variations of from 84.3 to 94.6 per cent., with an average of 90.41 per cent. Hills[3] found 87.9 and 90.1 per cent. in two lots of field pumpkins.

On the basis of the natural moisture the four lots of the fruit examined by us tested as follows: —

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[1] Landw. Versuchsstationen, 32, p. 231.

[2] After Ulbricht, already cited.

[3] Vermont Experiment Station, fourteenth report, Appendix, p. iv., and sixteenth report, Appendix, p. iii.

A. *Entire Fruit.*

SAMPLE.	Water.	Ash.	Crude Protein.	True Protein.	Amids (N×6.25).	Fiber.	Extract Matter.	Fat.	Reducing Sugars.	Sucrose.
1,	91.18	.67	1.56	1.20	.37	1.49	3.81	1.29	1.43	.80
2,	86.58	1.05	1.90	-	-	1.75	7.28	1.44	-	-
3,	84.08	1.16	2.49	-	-	2.29	8.24	1.74	-	-
4,	88.28	.97	1.74	-	-	1.84	5.67	1.50	-	-
Average,	87.53	.96	1.92	1.20	.37	1.84	6.25	1.49	1.43	.80

B. *Without Seeds and Supporting Tissue.*

SAMPLE.	Water.	Ash.	Crude Protein.	True Protein.	Amids (N×6.25).	Fiber.	Extract Matter.	Fat.	Reducing Sugars.	Sucrose.
1,	94.33	.50	.78	.45	.33	.98	3.26	.15	1.67	.32
2,	90.00[1]	.77	1.63	.79	.83	1.22	6.14	.24	2.60	1.89
3,	94.00[2]	.38	1.09	.33	.76	.98	3.43	.12	2.14	.57
Average,	92.78	.55	1.17	.52	.64	1.06	4.28	.17	2.14	.93

C. *Seeds.*

SAMPLE.	Water.	Ash.	Crude Protein.	True Protein.	Amids (N×6.25).	Fiber.	Extract Matter.	Fat.	Reducing Sugars.	Sucrose.
1,	43.00[1]	2.34	19.17	17.84	1.33	10.37	3.71	21.41	-	-
2,	47.00[2]	1.56	15.98	14.51	1.47	11.23	4.41	19.82	-	-
Average,	45.00	1.95	17.58	16.18	1.40	10.80	4.06	20.62	-	-

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[1] Ripe.

[2] Green.

A. Entire Fruit.

SAMPLE.	Ash.	Crude Protein.	True Protein.	Amids.	Fiber.	Extract Matter.	Fat.	Reducing Sugars.	Sucrose.
Average of 4,	7.70	15.40	9.62[1]	2.97[1]	14.76	50.19	11.95	11.47	6.42
B. Without Seeds and Supporting Tissue.									
Average of 3,	7.62	16.20	7.20	8.86	14.68	59.15	2.35	29.64	12.88
C. Seeds.									
Average of 2,	3.55	31.96	29.42	2.55	19.64	7.38	37.49	–	–
D. Roots and Grain for Comparison.									
Carrots (average),	10.26	10.26	–	–	9.40	68.38	1.70	–	–
Mangels (average),	10.64	14.89	–	–	8.51	64.89	1.07	–	–
Corn kernels,	1.50	11.00	–	–	2.20	80.90	4.40	–	–
Wheat kernels,	2.00	13.60	–	–	3.00	79.20	2.20	–	–

[1] One sample only.

In order to make a fairer comparison of the composition of the dry material, the average results, as shown in table on page 58, have been calculated to a water-free basis, as shown in table on page 59.

The whole pumpkin contains rather less ash than carrots or mangels, although it is much richer in mineral matter than the ordinary grains. The seed is much poorer in ash than the other portion of the fruit. The dry matter of the entire pumpkin contains rather more total protein than roots or grain, with a portion of it in the amido form. The seeds were found to be very rich in true protein. The fiber content of the fruit is noticeably higher than in roots. The seeds have more fiber than the other portion, due to the tough seed coat. Nearly all of the fat is contained in the seed, the analysis of the two samples showing an average of 37.49 per cent. The pumpkin contains large amounts of sugars; in the entire fruit one notes nearly 18 per cent., of which substantially one-third is in the form of cane sugar, while in the portion free from seeds 42.52 per cent. total sugars are noted. While sugar was not determined in the seeds, it is evident that they contain little, being made up chiefly of protein, fat and fiber.

Ulbricht [1] and Hills [2] made analyses of the ordinary field pumpkins, and Zaitschek,[3] of the so-called giant pumpkin (*Cucurbita maxima*), with the following results: —

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[1] Already cited.

[2] Vermont Experiment Station, fourteenth report, Appendix, p. iv., and sixteenth report Appendix, p. iii.

[3] Landw. Jahrbücher 35, p. 245.

	Ulbricht.				Zaitschek.				Hills.	
	Entire Fruit.	Entire Fruit, Dry Matter.	Seed less Skin.	Seed less Skin, Dry Matter.	Pulp.	Pulp, Dry Matter.	Seeds.	Seeds, Dry Matter.	Entire Fruit.	Entire Fruit, Dry Matter.
Water,	90.9	-	26.3	-	95.02	-	51.04	-	89.40	-
Ash,	.5	5.5	3.4	4.6	.53	10.55	2.12	4.32	.96	9.04
Crude protein,	1.3	14.3	26.5	35.9	.77	15.44	14.97	30.58	1.50	14.19
True protein,	-	-	-	-	.52	10.49	14.24	29.08	-	-
Fiber,	1.7	18.7	1.2	1.7	.65	13.04	7.81	15.96	1.50	14.11
Extract matter,	5.6[1]	61.5[1]	4.9	6.6	2.82	56.79	6.21	12.68	5.90	55.72
Fat,	-	-	37.7	51.2	.21	4.18	17.85	36.46	.74	6.95
Pentosans,	-	-	-	-	.26	5.17	2.62	5.36	-	-
Calories per 100 grams,	-	-	-	-	20.55	412.40	305.90	624.80	-	-

[1] Including fat.

These figures agree with those secured in this laboratory. They show a high water content in the natural fruit and a relatively high percentage of crude protein. The seed is shown to be particularly rich in protein and oil, and quite low in carbohydrate matter.

DIGESTIBILITY OF PUMPKINS.

A number of digestion trials were made in two successive years, using two sheep in each case. The pumpkins were fed together with hay and also with hay and gluten feed as basal rations. The entire details of the experiment will be published elsewhere. The coefficients of digestibility only are given in the table on page 63.

A. *Entire Fruit.*

YEAR.	Sheep No.	Hay fed (Grams).	Gluten Feed fed (Grams).	Pumpkin fed (Grams).	Dry Matter digested (Per Cent.).	Ash digested (Per Cent.).	Crude Protein digested (Per Cent.).	Fiber digested (Per Cent.).	Extract Matter digested (Per Cent.).	Fat digested (Per Cent.).
1913–14,	1	550	–	2,000	75.87	64.82	70.50	59.74	81.54	96.29
1913–14,	2	550	–	2,000	89.32	63.93	80.69	86.30	98.12	96.87
1914–15,	1	500	–	2,000	81.62	70.96	67.89	65.20	90.84	89.27
1914–15,	2	500	–	2,000	88.23	62.99	67.20	83.59	96.40	91.76
1914–15,	1	550	150	1,200	78.80	68.35	83.63	47.80	86.30	88.10
1914–15,	2	550	150	1,200	75.41	49.82	82.57	46.23	83.83	84.69
1914–15,	1	412	112	2,000	75.57	76.95	74.81	38.49	83.82	94.23
Average,	–	–	–	–	80.69	65.40	76.61	61.05	88.69	91.60

B. *Pumpkins minus Seeds and Supporting Tissue.*

YEAR.	Sheep No.	Hay fed (Grams).	Gluten Feed fed (Grams).	Pumpkin fed (Grams).	Dry Matter digested (Per Cent.).	Ash digested (Per Cent.).	Crude Protein digested (Per Cent.).	Fiber digested (Per Cent.).	Extract Matter digested (Per Cent.).	Fat digested (Per Cent.).
1913–14,	1	500	–	2,000	109.23	105.13	92.55	137.52	108.99	101.44
1913–14,	2	500	–	2,000	93.84	59.48	93.96	95.16	102.44	83.81
Average,	–	–	–	–	101.54	82.31	93.26	116.34	105.72	92.63

One notes wider variations in the digestibility of the different ingredients by the two sheep than are desirable. Thus, there are extremes of from 75.41 to 89.32 per cent. in case of the dry matter; 67.20 to 83.63 per cent. in case of the protein; and still wider variations in the fiber.

The coefficients for the pumpkins minus the seeds and connecting tissue are much higher, and indicate that if the seeds had been removed the animals would have digested practically the entire fruit.

Careful observations failed to note any whole seeds or large portions of seeds in the fæces. It seems evident that in case of sheep No. 1 the pumpkins must have exerted a favorable influence on the digestibility of the hay.

Zaitschek carried out digestion experiments on the Giant pumpkin with two steers, feeding a combination of hay and pumpkins. His results are tabulated below in addition to our own for comparison.

SOURCE.	Numbers of Trials.	Dry Matter.	Organic Matter.	Ash.	Crude Protein.	True Protein.	Fiber.	Extract Matter.	Fat.	Pento-sans.	Energy.
Massachusetts Station (2 sheep), .	8	80.7	-	65.4	76.6	-	61.0	88.7	91.6	-	-
Zaitschek (2 steers), . . .	2	81.4	82.3	72.6	70.3	63.7	67.5	89.4	90.1	68.7	80.1

In spite of the variations in results secured at this station with sheep, our average results agree surprisingly well with those secured by Zaitschek.

Applying the digestion coefficients to the composition of the pumpkin in its natural state, we have the following digestible organic nutrients in 2,000 pounds: —

	Source.	Water (Per Cent.).	Crude Protein (Pounds).	Fiber (Pounds).	Extract Matter (Pounds).	Fat (Pounds).	Total (Pounds).	Total plus Fat ×2.2.	Relative Values.
Pumpkins,	Massachusetts Station,	87.53	29.4	22.4	110.9	27.3	190.0	222.8	100.0
	Zaitschek,	93.89	15.9	12.7	52.0	11.9	92.5	106.8	–
Mangels,[1]	Massachusetts Station,	88.00	20.0	6.0	154.0	–	180.0	180.0	80.7
Ruta baga,[1]	Massachusetts Station,	89.00	20.0	20.0	136.0	2.0	178.0	180.4	80.8

[1] For comparison.

The above data indicate that on the basis of substantially the same water content, 2,000 pounds of pumpkins contain some 9 pounds more of digestible crude protein, 16 pounds more of digestible fiber, 43 pounds less digestible extract matter, and some 27 pounds more digestible fat than are contained in a like amount of mangels. Mangels, then, are richer in carbohydrate matter, but less rich in protein and particularly in fat than is the pumpkin. The pumpkin contains more digestible protein than the ruta baga, about the same amount of fiber, rather less carbohydrate matter and noticeably more fat. On the basis of total digestible nutrients, allowing for the increased energy value of the fat, the two roots appear to have about 20 per cent. less feeding value than the same weight of pumpkin. These figures, of course, cannot be taken too literally. It is doubtful if the computation of net energy values — because of the scantiness of the data — would throw any additional light on the relative values of the several feeds.

FEEDING EXPERIMENTS WITH PUMPKINS.

A number of experiments are recorded relative to the value of pumpkins as a feed for cows and pigs. Hills [1] fed three cows in three periods of fifty-four days each on hay, silage, a grain mixture and pumpkins. During the first and third periods the cows received the hay, silage and grain, and in the second period, hay, silage, grain and pumpkins. Two and one-half pounds of pumpkins with 90.1 per cent. of water were substituted for 1 pound of silage, with apparently like results.

In a second experiment with four cows, feeding pumpkins in the second of three periods at the rate of 40 pounds per cow daily, he concluded that 6½ pounds of pumpkins with 87.9 per cent. water were equal to 1 pound of hay.

French [2] fed six Berkshire pigs that were eight months of age on a ration of wheat shorts and field pumpkins (cooked) with the seeds removed. The experiment covered five periods of eighty-four days each, and in the last two periods the pigs consumed an average each of 26 pounds of pumpkins per day. The average daily gain in live weight was 1.5 pounds, and the results were considered quite satisfactory.

Burkett [3] fed several lots of three pigs on combinations of skim milk, corn meal and pumpkins cooked and uncooked; also on milk and raw pumpkins *versus* milk and corn meal; and on milk, pumpkins and apples, half and half, cooked, *versus* milk, corn meal and bran, half and half. The general conclusion was that cooking did not increase the feeding value of pumpkins, and that a combination of skim milk, corn meal and pumpkins gave the most satisfactory results.

Pott [4] reports that in England pumpkins are quite generally fed to fattening pigs, together with ground barley and beans; also to milch cows at the rate of 25 to over 100 pounds daily, cut fine and mixed with cut straw; and to fattening cattle as high as 100 pounds daily, preferably cooked. Pumpkins are also fed in Austria to cows, fattening cattle, pigs and horses. Pott states that the claim made that the seeds are injurious is without foundation.

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[1] Already cited.

[2] Oregon Experiment Station, Bul. No. 53, p. 22.

[3] New Hampshire Experiment Station, Bul. No. 66.

[4] Handbuch der tierischen Ernährung, etc., II. Band, pp. 424, 425.

Feeding Pumpkins to Milch Cows at this Station.

In order to observe the effect of pumpkins upon the quantity and quality of milk and on the general condition of the animals, two grade Jersey cows were selected and fed with 30 pounds each of pumpkins daily, in addition to hay and grain. The data and plan are as follows: —

History of Cows.

Name.	Breed.	Age (Years).	Last Calf dropped.	Approximate Milk Yield (Pounds).	Fat (Per Cent.).	Weight of Cows (Pounds).
Samantha, . . .	Grade Jersey.	11	August 25	36.7	4.1	950
Red III., . . .	Grade Jersey.	9	August 11	23.5	3.9	910

Plan and Duration of Experiment.

The two cows were fed in three distinct periods of twenty-one days each, exclusive of the preliminary periods. In the first period they each received a ration of hay, bran and cottonseed meal and hominy meal; in the second period the same ration, excepting that 5 pounds of the hay were replaced by 30 pounds of the pumpkins; in the third period the ration fed was the same as in the first period. The results secured in the first and third periods were averaged and compared with those secured in the second. Five pounds of hay were therefore compared with 30 pounds of pumpkins.

Care of Animals. — The animals were well cared for and turned into a barnyard about eight to nine hours each day. They were fed twice daily; the hay was given sometime before milking and the grain just before milking, while in the morning the grain was given just before, and the hay just after, milking. Water was supplied constantly by aid of a self-watering device.

Character of Feeds. — The hay and grains were of the usual good quality. The pumpkins were grown by one farmer and were the ordinary yellow field variety of different sizes. Most of them were ripe.

Sampling Feeds and Milk. — The hay was sampled at the beginning and end of each period by taking forkfuls of the daily weighing, running the same through a power cutter, subsampling and placing the laboratory samples in large glass-stoppered bottles with proper markings. The grains were sampled daily by placing definite amounts in glass-stoppered bottles, and these bottles properly labeled were brought to the laboratory at the end of each period.

The pumpkins were cut into small pieces before being fed.

The analytical data serving for the digestion experiment also served for this experiment.

Analysis of the Milk. — The milk of each cow was sampled daily for five consecutive days of the last two weeks of each period, the samples preserved with formalin, and the five-day composite sample tested for solids and fat.

Weighing the Animals. — The animals were weighed for two consecutive days at the beginning and end of each half of the period before the afternoon feeding.

Analysis of Feedstuffs.

	Water.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Hay,	11.34	5.16	5.14	31.03	45.57	1.76
Bran,	12.45	6.47	15.73	10.27	50.68	4.40
Cottonseed meal,	8.81	6.37	41.63	10.19	25.91	7.09
Hominy meal,	11.24	2.05	10.41	4.48	64.67	7.15
Pumpkins,	84.77	1.14	2.50	2.10	7.77	1.72

Total Feed consumed (Pounds).

Average, Periods I. and III.

NAME.	Hay.	Bran.	Cottonseed Meal.	Hominy Meal.	Pumpkins.
Red III.,	378	63	42	42	-
Samantha,	504	84	63	84	-

Period II.

NAME.	Hay.	Bran.	Cottonseed Meal.	Hominy Meal.	Pumpkins.
Red III.,	273	63	42	42	630
Samantha,	399	84	63	84	630

Daily Feeds consumed (Pounds).

Hay + Grain (Periods I. and III.).

NAME.	Hay.	Bran.	Cotton-seed Meal.	Hominy Meal.	Pump-kins.
Red III.,	18	3	2	2	-
Samantha,	24	4	3	4	-

Hay + Grain + Pumpkins (Period II.).

NAME.	Hay.	Bran.	Cotton-seed Meal.	Hominy Meal.	Pump-kins.
Red III.,	13	3	2	2	30
Samantha,	19	4	3	4	30

Estimated Digestible Nutrients in Daily Rations.

Hay + Grain (Periods I. and III.).

NAME.	Protein.	Fiber.	Extract Matter.	Fat.	Total.	Nutritive Ratio.
Red III.,	1.73	3.60	7.63	.53	13.49	1:7.2
Samantha,	2.51	4.86	11.03	.83	19.23	1:7.1
Average,	2.12	4.23	9.33	.68	16.36	-

Hay + Grain + Pumpkins (Period II.).

NAME.	Protein.	Fiber.	Extract Matter.	Fat.	Total.	Nutritive Ratio.
Red III.,	2.16	3.05	8.31	.97	14.49	1:6.2
Samantha,	2.95	4.31	11.71	1.27	20.24	1:6.4
Average,	2.55	3.68	10.01	1.12	17.36	-

The above nutrients were estimated on the basis of actual analysis and the application of average digestion coefficients. The 30 pounds of pumpkins fed contained 1 pound more digestible nutrients than 5 pounds of hay. This was due to the fact that the pumpkins had rather less water than was expected, and that they contained such a high percentage of digestible matter. On the basis of digestible matter, 1 pound of hay is equivalent to some 4½ pounds of pumpkins.

Weights of the Animals (Pounds).

	RED III.			SAMANTHA.		
Period,	I.	III.	II.	I.	III.	II.
Beginning,	915	930	905	1,095	1,153	1,095
End,	948	930	928	1,140	1,148	1,118
Gain or loss,	+33	±	+23	+45	—5	+23
Average,	+17		+23	+20		+23

Gain or Loss for Both Cows.

Periods I. and III. (hay+grain) = 37 pounds+.

Period II. (hay+grain+pumpkins) = 46 pounds+.

There seems to have been very little difference in the changes in weight as a result of feeding the two rations.

Total Yield of Milk Products.

Hay+Grain (Period I.).

NAME OF COW.	Total Milk (Pounds.	Daily Milk (Average).	Total Solids (Pounds).	Total Fat (Pounds).	Average Per Cent. Total Solids.	Average Per Cent. Fat.
Red III.,	364.4	17.4	47.88	17.49	13.14	4.80
Samantha,	532.1	25.3	76.73	29.11	14.42	5.47

Hay+Grain (Period III.).

Red III.,	301.6	14.4	42.07	16.47	13.95	5.46
Samantha,	460.0	21.9	69.18	26.40	15.04	5.74

Hay+Grain+Pumpkins (Period II.).

Red III.,	341.7	16.3	48.15	19.24	14.09	5.63
Samantha,	495.3	23.6	76.08	29.87	15.36	6.03

Total Yield of Milk Products — Concluded.

Hay + Grain (Average, Periods I. and III.).

NAME OF COW.	Total Milk (Pounds).	Daily Milk (Average).	Total Solids (Pounds).	Total Fat (Pounds).	Average Per Cent. Total Solids.	Average Per Cent. Fat.	Average Per Cent. Solids not Fat.
Red III.,	333.0	15.9	45.09	17.08	13.54	5.13	8.41
Samantha,	496.1	23.6	73.08	27.83	14.73	5.61	9.12
Average,	414.6	19.7	59.09	22.46	14.25	5.42	8.83
Hay + Grain + Pumpkins (Period II.).							
Red III.,	341.7	16.3	48.15	19.24	14.09	5.63	8.46
Samantha,	495.3	23.6	76.08	29.87	15.36	6.03	9.33
Average,	418.5	19.9	62.12	24.56	14.84	5.87	8.97

The yield of milk was substantially the same on each ration. The total solids showed an increase as a result of feeding the pumpkins, and this was due evidently to an increase in the percentage of fat in the milk. Attention has been called to the fact that the pumpkin seeds are rich in fat. By referring to the average daily rations consumed (page 69) it may be seen that the ration without pumpkins contained .68 pound daily of digestible crude fat, and with the pumpkins 1.12 pounds, the excess of .44 pound of pure fat being derived from the pumpkin seeds. This additional food fat evidently temporarily increased the fat in the milk.

In so far as the results of a single experiment with two cows are concerned it appears that 6 pounds of pumpkins fully replaced 1 pound of hay. On the basis of digestible nutrients our calculations show that 4½ pounds of pumpkins with 84.8 per cent. of water replaced 1 pound of hay with 11.34 per cent. of water. It is quite possible that 25 pounds of pumpkins would have replaced 5 pounds of hay with equal results. Because of the rather wide variations in the moisture content of the fruit, one could say only on the basis of results secured, that from 5 to 6 pounds of pumpkins were equivalent to 1 pound of first-class cow hay.

BULLETIN No. 175.

DEPARTMENT OF BOTANY.

MOSAIC DISEASE OF TOBACCO.[1]

BY G. H. CHAPMAN.

INTRODUCTION.

The observations and conclusions reported in the following pages are the results of several years of more or less continuous investigation on the part of the writer, and deal with the probable causes, occurrence, appearance and methods of control of this well-known disease of tobacco and related plants. Enough has been accomplished so that it is believed wise to add still another paper to the already long list of literature which has been published on this disease. During the time in which these experiments have been in progress much new literature has appeared dealing with this subject, some of which has helped the writer by verifying his results and by bringing out new facts concerning the disease; but, on the other hand, some of the work appears to have been done in a hasty manner, and possibly erroneous conclusions drawn in some cases, thus adding to the large amount of confusing subject-matter which has to do with this disease. The experiments carried on by the writer were begun in a general way in 1907, and have been repeated several times during the years subsequent to that date, new lines of investigation both in the field and laboratory having been added as occasion demanded. Some considerable time has been spent in verifying the results obtained by other recent investigators, and an attempt has been made to gather together in a broad, general way, as well as in detail, all the reliable information possible about this interesting disease, as well as to bring out new facts in regard to it. More attention has been given to the biochemical aspects of the problem than has heretofore been done by investigators.

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[1] Also presented in part to the faculty of the graduate school of the Massachusetts Agricultural College, June, 1916, as a major thesis in partial fulfillment of the requirements for the degree of doctor of philosophy.

HISTORICAL SUMMARY.

In the following paragraphs is given a brief résumé of the more important work done on the mosaic disease of tobacco up to the present time, and as an excellent critical review of the literature, etc., up to 1902 is given by A. F. Woods [1] in his work on the subject, the same is quoted in full below. He states: —

> Adolph Mayer [2] was the first to make a careful study of the trouble. He demonstrated that it could not be caused by an insufficient supply of mineral nutrients. He found as much nitrogen, potassium salts, phosphates, calcium and magnesium present in the soils and plants where the disease occurred as in the soils where the disease did not occur. He also found that the trouble was apparently distributed over the field without regard to the soil conditions.
>
> Since tobacco requires much lime, liming the soil was tried, but the disease was not prevented thereby. Mayer further kept hotbeds in some cases rather moist, in others dry, and then again, richly or poorly manured with nitrogen; but in no case could he determine that the conditions in question caused the disease. He also found that variations in the temperature of the hotbeds apparently had no effect; neither did crowding, which produced partial etiolation, appear to have any effect on the disease. Seeds from flowers in which self-fertilization was prevented he found to be just as susceptible to the disease as seeds produced without such precautions, but on the soil on which the disease had once appeared it was again produced. According to his observation, also, the trouble was not often found on soil used for the first time for tobacco. He further proved that the juice of the diseased leaves injected with the juice of healthy plants did not develop the disease. He was not able to produce it by injecting diseased juice into other solanaceous plants. Where the diseased juice was injected into tobacco the same trouble developed in from ten to eleven days. Heating to 60° C. did not destroy the infectious substance; at 65° to 75° it was attenuated, and at 80° it was killed.
>
> After Mayer had shown the absence of animal and fungous parasites he supposed bacteria to be the cause of the disease, but all his efforts with bacteria cultivated from the surface of diseased leaves, and also with different mixtures of bacteria, failed to produce it. Nevertheless, he thought that there must be certain pathogenic bacteria present in those soils in which the disease appeared, and therefore proposed to change the soil in the hotbeds and to devote the fields where tobacco had been cultivated to other crops. He also recommended the use of mineral rather than organic manures.
>
> These general results were confirmed by several subsequent investigators. Not, however, till Beijerinck [3] took hold of the question was much of importance added to our knowledge of the malady. He proved the absence of bacteria in the development of the disease. He showed that the juice of the plant filtered through Chamberland filters, while remaining perfectly clear and free from bacteria, still retained the power of infection. A small drop of it injected hypodermically into the growing bud was sufficient to give the plant the disease. He found that only dividing (meristematic) cells can become diseased. Diseased tissue kept its infectious qualities even after drying, and retained its injurious properties in the

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[1] Woods, A. F.: Observations on the Mosaic Disease of Tobacco. U. S. D. A., Bur. Plant Ind., Bul. No. 18 (1902).

[2] Mayer, Adolph: Über die Mosaikkrankheit des Tabaks. Landw. Versuchsstation, 32: 451-467 (1886). Review of the same article in Journ. of Mycology, 7: 382-385 (1894).

[3] Beijerinck, M. W.: Verhandelingen der Koninklijke Akademie van Wetenschappen te Amsterdam. Deel 6: No. 5. See also Centb. f. Bakt., Par., etc., II: 5: 27-33 (1899).

soil during the winter. Weak solutions of formalin did not kill the virus, but heating to boiling point did. Fresh, unfiltered juice was more effective than an equal amount of filtered juice. He found that soil around diseased plants may infect the roots of healthy plants, but he did not determine whether direct transference is possible through healthy root surfaces, or whether insects, by injuring the roots, favored infection. He defines the milder form of the disease as a suffering of the chlorophyll bodies. Later a general disease of the plasmatic contents of the cells sets in.

In field conditions as a final stage the swollen green areas become marked with small dead spots, but these did not appear on plants grown under glass. Under certain conditions he observed that plants apparently recover from the disease; *i.e.*, the new growth appeared to recover. He found that the infective material, whatever it might be, could be transported through considerable distances in the plant, but could cause the disease only in the dividing cells. He assumed the virus to be a non-corpuscular, fluid-like material, which had the power of growth when in contact, in a sort of symbiotic way, with the growing cells, — "a living fluid contagium."

Shortly after Beijerinck's paper, Sturgis[1] published a critical review of the work done on the disease up to that time, with numerous valuable results and observations made in Connecticut, where the trouble is known as "calico" or "mottled top."

The results obtained by Sturgis and observations made by him on tobacco in Connecticut bore out the statements of other careful and critical workers, and greatly cleared up the field for further investigation. He came to the conclusion that on close, clayey soils the disease may be more abundant than on an open, porous soil. The disease is not contagious, but he could not state definitely as to its infectiousness; it is not caused by fungi, nematodes or parasitic insects, and the facts observed by him were not favorable to the theory of bacterial origin. He also came to the conclusion that the disease is not inherent in the seed, and looked upon it as a purely physiological trouble brought about by sudden interruptions of the normal plant metabolism. Koning,[2] in his work, verified much of the work of Beijerinck and Mayer, and Woods[3] later verified the work of these investigators and pointed out that in the diseased leaves there was an excess or excessive activity on the part of an enzyme belonging to the oxidases, and that the power of oxidation in the cells was inversely proportional to the amount of chlorophyll present, using the color as a basis of comparison. He also pointed out that there was a marked structural difference between the cells of the dark green and light green areas, and proved to his own satisfaction that the light green areas are the truly diseased portions, a fact that will be referred to later in this paper. In a later careful investigation of the disease Woods[4] arrived at the following conclusions, which were a great stride forward in our understanding of some phases of this baffling disease. He states: —

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[1] Sturgis, W. A.: Mosaic Disease of Tobacco. Conn. Agr. Exp. Sta. Rept., 250–254 (1898).

[2] Koning, C. J.: Die Flecken oder Mosaikkrankheit des hollandischen Tabaks. Zeitschrift für Pflanzenkr., 9: 65–80.

[3] Woods, A. F.: Inhibiting Action of Oxidase on Diastase. Science, n. s., No. 262, 17–19.

[4] Woods, A. F., *loc. cit.*

The disease is not due to parasites of any kind, but is the result of defective nutrition of the young dividing and rapidly growing cells, due to a lack of elaborated nitrogenous reserve food accompanied by an abnormal increase in the activity of oxidizing enzymes in the diseased cells. The unusual activity of the enzyme prevents the proper elaboration of the reserve food, so that a plant once diseased seldom recovers. On the decay of the roots, leaves and stems of both healthy and diseased plants, the enzyme in question is liberated and remains active in the soil. The enzyme is very soluble in water and appears to pass readily through plant membranes. If the young plants take it up in sufficient quantity to reach the terminal bud, they become diseased in the characteristic way. Under field conditions there is little danger from infection in this manner, but in the seed bed the danger is much greater on account of the greater susceptibility of the young plants to the disease, and the greater amount of free oxidizing enzymes likely to be in the soil due to the decay of the roots and plants. New or steam sterilized soil should therefore be used for the seed bed.

I have shown that transplanting, especially when the roots are injured, may produce the disease. Great care must, therefore, be taken not to injure the roots in this process or in the subsequent cultivation, or to check the growth of the plants.

There is evidence that rapid growth, caused by too much nitrogenous manure or too high a temperature, is favorable to the disease. Why this should be the case has not been determined. It is probably connected with the manufacture of reserve nitrogen by the cells and its distribution to the rapidly growing parts.

Plants grown under such conditions are less able to stand successfully marked variations in temperature and moister conditions of soil and atmosphere. Variations of this kind favor the development of the disease in the less resistant plants.

Close, clayey soils, packing hard after rains and requiring constant tillage, are not favorable to the even growth of either the tops or roots of tobacco plants. In moist, cloudy weather the plants will grow too fast, and in hot, dry weather the soil is likely to bake, checking growth and making probable injury to the roots in cultivation. Such soils are very favorable to the development of the mosaic disease, as pointed out by Thaxter.[1] He found that loosening the soil by liming and giving partial shade, thus causing a more even condition of growth, very greatly reduced the disease.

Crops grown under cheesecloth covers protected at the side are said to be remarkably free from the disease. The plants make a steady rapid growth, much greater than in ordinary field culture. . . .

The disease is not, so far as observed, produced by a lack of soil nutrients, though from its nature we would expect that a deficiency of nitrogen, phosphoric acid, lime and magnesia might favor its development. Koning[2] says that manuring with kainit and Thomas slag diminishes the extent of the disease. Mayer, Beijerinck and other investigators, however, agree that the trouble is not caused by the lack of any soil nutrients. It appears, so far as my own investigations go, that the trouble cannot be cured by giving the plants additional food of any kind. Overfeeding with nitrogen favors the development of the disease, and there is some evidence that excess of nitrates in the cells may cause an excessive development of the ferments that cause the disease. Very slight attacks of the disease known as "mottled top" are said not to injure the quality of the leaf to a sufficient extent to be noticeable commercially, though they may be less elastic and have a poorer burn and aroma than healthy leaves.

Hunger,[3] in his work on the mosaic of Deli tobacco, verified much of the work of previous investigators, and later, in carefully planned and executed experiments,[1] proved that the disease was not contagious but was highly infectious. He believed that it could be carried from diseased to healthy leaves simply by touching, especially in the case of the young leaves, a fact that makes it necessary for the workman to use great care when looking for the tobacco bud worms, etc., in the buds. He was of the opinion that a rupture of the leaf was not necessary to induce the mosaic disease in plants.

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[1] Thaxter: Conn. Agr. Exp. Sta. Rept., III, 253 (1899).

[2] Koning, C. J., *loc. cit.*

[3] Hunger, F. W. T.: De Mozaiek-ziekte bij deli Tabak. Med. s'Lands Plantentium, Batavaia. Deel 1: 63 (1903).

Selby[2] a year later showed this to be apparently true for tobacco grown in Ohio, and Hunger's statements were in his opinion in all respects confirmed. He also reported that "Blossoms of various plants were inoculated through the nectar by transmission of nectar from diseased plants, as by insect visitation. A slender brush of horse hair was used for this purpose. No evidences of the disease were observed as a result of this method."

Clinton[3] was able to produce the trouble on tomatoes by inoculating with juice from a diseased tobacco plant and from the tomato so infected was able to reproduce the disease on the tobacco again by inoculation from the tomato, again showing the infectious nature of the disease, and that the troubles on the tomato and tobacco were practically identical. This has been repeatedly verified by the writer and many other investigators.

Jensen,[4] in his work on the disease, came to the conclusion that the right way to get at the methods of control of the disease was by experimentation to obtain a resistant strain of tobacco, no matter what the cause of the disease might be, and he carried on some experiments along these lines. As yet no definite results have been reported by the investigators, but the time has probably been too short to obtain results.

Lodewijks[5] stated that by subjecting diseased plants to different colored lights he was able to bring about a cure in some cases. He states: —

> The mosaic disease cannot be diminished or prevented by lessened light intensity. Neither diffused nor colored light has any effect on the disease if the healthy leaves are not able to function in normal daylight. Under the latter condition, however, diffused light exerts a retardation, red light diminishes the trouble, and blue light effects a cure. All the results may then be explained by the hypothesis that the virus formation diminishes with the intensity of the light, while in the healthy leaves, through the action of the virus, an anti-virus is formed, the action of which destroys the virus (immunity and antitoxin formation in the case of animals). . . .
>
> Normally in the metabolism of the tobacco plant a substance is formed, the action of which is opposed to that of the equally normally occurring virus of mosaic disease, perhaps because it binds itself chemically to the latter.

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[1] Hunger, F. W. T.: Die Verbreitung der Mosaikkrankheit infolge der Behandlung des Tabaks. Centralbl. f. Bakt. Par., etc., II: 11: 405–408 (1908).

[2] Selby, A. D.: Tobacco Disease. Ohio Agr. Exp. Sta. Bul. No. 15, 88–95 (1904).

[3] Clinton, G. P.: Notes on Fungous Diseases, etc. Conn. Agr. Exp. Sta. Rept., 1907–08, 857–858.

[4] Jensen, H.: Über die Bekampfung der Mosaikkrankheit der Tabakpflanze. Centralbl. f. Bakt. Par., etc., II: 15: 440–445 (1906).

[5] Lodewijks, T. A., Jr.: Zur Mosaikkrankheit des Tabaks. Rec. Trav. bot. Neerlandais, VII. (1910).

> Both substances, virus and anti-virus, may be increased by external factors or conditions. In the first instance the plants become diseased with the mosaic disease; in the latter an immunity against the disease is brought about. Decrease in intensity and cure occur if the virus formation ceases or stops, while at the same time the formation of an anti-virus is taking place normally or is increased.[1]

A discussion of Lodewijks' work is to be found later in this paper.

Allard[2] in a recent work on the disease states that from the results of his experiments he is of the opinion that the trouble is not primarily physiological but is parasitic in nature, but he is unable to throw any light on the nature of the parasite, and in spite of the conclusions drawn by him, none of his results, at least in so far as the writer is able to judge, has in any way weakened the theory that the trouble may be physiological in nature; and some of his results, from the writer's point of view, seem to substantiate this idea of a physiological agency. Two points of great interest are brought out by him, viz., the mosaic as affecting the color of the corolla by blotching, etc., and the carrying of the disease by certain aphids. These points have not been noted before. In the following pages some of his work will be taken up in detail in so far as it seems to bear out or refute work done by the writer.

It may be seen from the foregoing résumé that the theory that the disease is physiological in character has been in the past pretty generally accepted, but the identification of the ultimate causes producing the symptoms varies widely with the different investigators. The writer's conclusions with regard to this point are taken up later in this paper.

Names.

By right of priority the term "mosaic" is the one which should be applied to this disease. It has, however, many local names, and these sometimes are applied differently to the different manifestations of the symptoms; among them may be mentioned the following: "calico," "brindle," "mongrel," "mottle-top," "string leaf," "frenching," etc. Other terms have also been used, but they do not in all cases apply to the "mosaic" alone, hence they are here omitted. The term "infectious chlorosis" as suggested by Clinton is perhaps best descriptive of diseases of this general character, with "mosaic" as a specific type under this division, there being many other infectious, chlorotic diseases of plants quite distinct from the mosaic type.

Description of the Mosaic Disease of Tobacco.

Descriptions of the mosaic disease of tobacco have been repeatedly presented, and the disease itself is so well known that there is little need of repetition at this point, but a brief résumé of the salient characteristics of the disease will be given so that no misunderstanding may arise, as several other leaf troubles more or less chlorotic in character have often been confounded with the true "mosaic." The disease may show on the leaves at all stages of the growth, from the seedling to the mature plant. It is often difficult in seedlings to diagnose the trouble definitely, as the slight mottling and curl of the leaves may be due to other factors. As a rule, in young plants the leaf is rougher and a *permanent* mottling is observed, very slight in character, however, and not to be confounded with the mottling due to normal metabolic processes which occurs under certain conditions of growth. As the disease progresses, however, the leaf is found to be divided into light and dark green areas; in mild cases there does not appear to be any marked leaf distortion, and the light green areas sometimes verge on the yellow in color. The dark green areas apparently deepen in color with the intensity of the disease, and in extreme cases the leaf is much distorted and the dark portions appear blister-like, due to their more rapid growth. The leaves, as a rule, are much stiffer and thicker to the touch than are the normal healthy leaves. Sometimes in the later stages of the disease there are found dry, dead, brown patches or spots on the leaves, sometimes where the dark green areas were originally, but more often the light green portions show this extreme condition. Both the light and dark areas show abnormalities in structure; nevertheless, the light green areas are the more truly diseased ones, the dark green areas presenting different characteristics, and although showing changes in cell arrangement, etc., function more normally in many respects. Most investigators have held that the light green areas are the diseased portions of a leaf, but some have been of the opinion that the dark green areas are the diseased portions. As will be seen from the writer's experiments the former is the more correct view, as the increase in color intensity and the blistering of the dark green areas is due to the necessarily increased functioning thrown on these portions of the leaf.

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[1] Translation from abstract of Lodewijks' paper in Bot. Centralbl., 114-518 (1910).

[2] Allard, H. A.: Mosaic Disease of Tobacco. U. S. D. A., n. s., Bur. Plant Ind., Bul. No. 40 (1914).

Occasionally a leaf may be distorted in such a manner as to present the appearance of being little more than a long filament consisting principally of midrib, with but very little leaf surface. This condition has been observed by the writer in some instances, but should not be confounded with a similar trouble occurring on tobacco in certain regions, which is of an unknown character but which is not the true mosaic as it is not infectious. This latter trouble has been noted particularly in Java, etc., as is reported by Peters[1] in his work on the diseases of tobacco. It has not been observed in tobacco fields in this region by the writer.

It is thought that soil and moisture conditions are responsible at least partially for this disease.

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[1] Peters, L.: Krankheiten und Beschadigung des Tabaks. Mitteil. aus der Kaiser. Anstalt F. Land- u. Forstwirtschaft. Heft, 13: 64 (1912).

OCCURRENCE.

The mosaic disease has been known for years both in Europe and America, and may be said to be present everywhere that tobacco is grown. It apparently is a more serious disease in the tropics and in certain parts of Europe than it is in this country. In New England it has been known for some time, and, although present to a certain extent each year, is not of such great economic importance as in some other localities. In Massachusetts it is found practically everywhere, and some years appears to be much more prevalent over widespread areas than in others. As a rule, however, the disease is not epidemic in character, and often only a comparatively few plants in a field will be found affected.

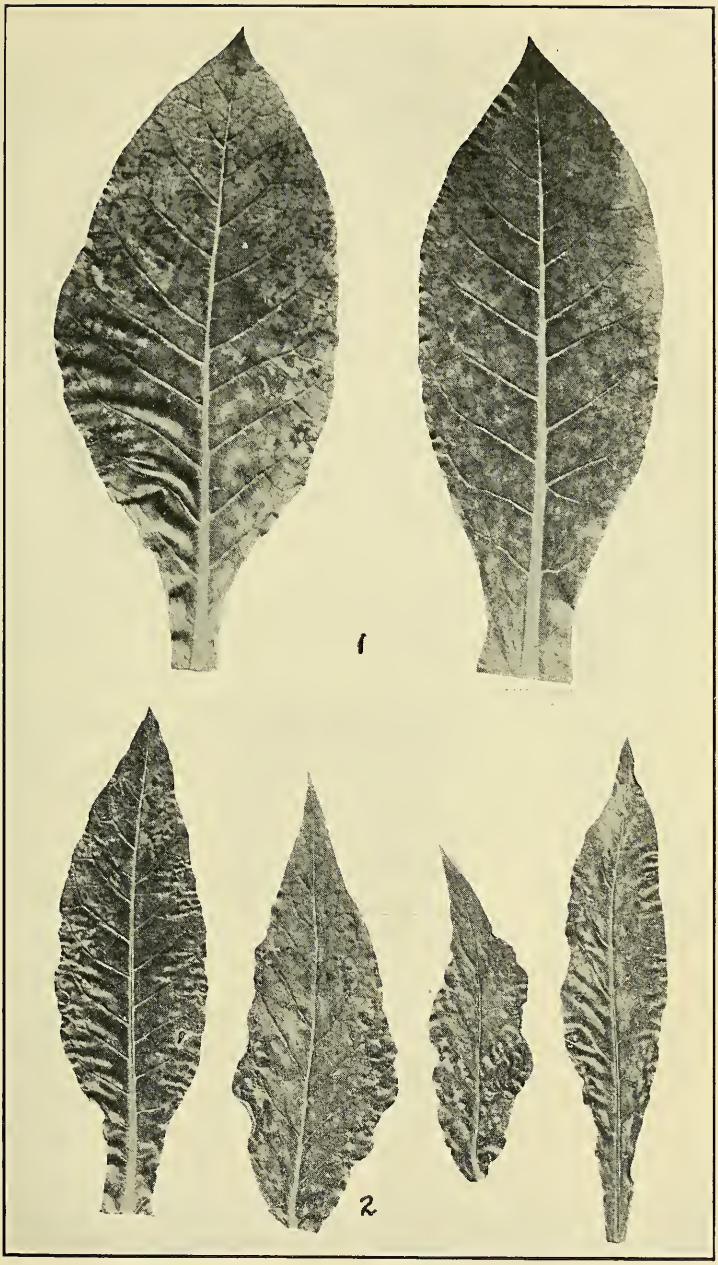
On certain fields, however, — and these most often are such as have been cropped to tobacco for many years without the practice of cover-cropping or rotation, — mosaic disease is present year after year, and a large percentage of the crop is always badly affected, the plants beginning to show the trouble in from three to four weeks after planting in the field.

The prevalence of the disease in the field, aside from the special cases above noted, is apparently related in some way to conditions in the field during the growing season, or during the time the plants are in the seed bed. There is no question that a large percentage of the infection found in the field, exclusive of that appearing on the sucker growth after topping, or due to infection at the time of transplanting, is due to a primary infection from the seed bed.

While the disease as a rule is first noticed in the field some time after transplanting, very often the seedlings in the beds are affected. This is particularly true in the case of old or carelessly treated beds. It is often very difficult for the casual observer to identify the disease on the seedlings, as the macroscopic or visible symptoms are either very slight or lacking. In this way many plants are transplanted to the field by workmen without their being aware that they are diseased, and the disease becoming more pronounced in the later stages of growth, the infection is laid to the soil in the field, when in reality the infected soil of the seed bed is responsible and not the field soil. As has been stated, the closest examination of the seedlings is necessary to identify the trouble in the seed bed, particularly in mild cases of infection.

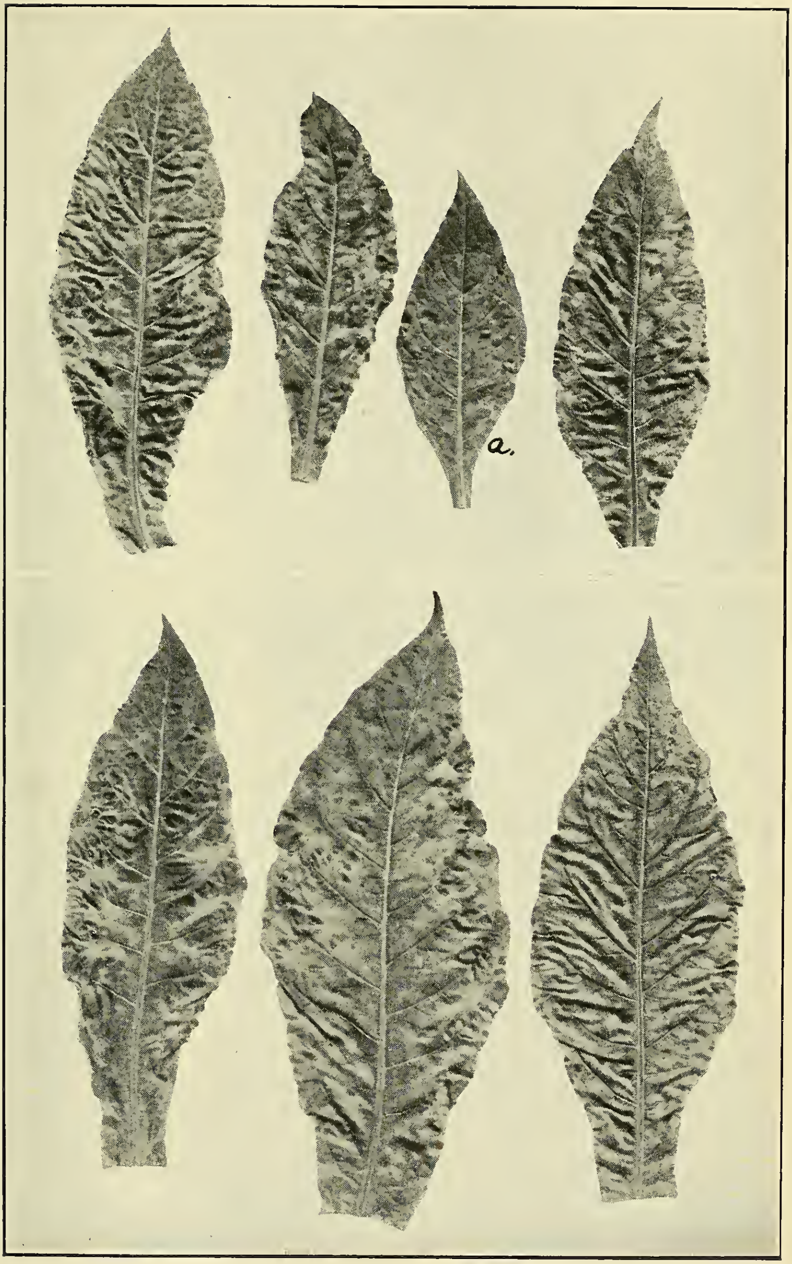
From observations made repeatedly, not only on seed beds but also experimentally under controlled conditions in the greenhouse with soils from old beds, afterwards transplanting the seedlings to soil previously not used for tobacco, and using as checks healthy plants from new soil, the writer has come to the conclusion that at least 80 per cent. of our field infections come from the seed bed and *do not* originate in the field as is commonly supposed.

PLATE I.



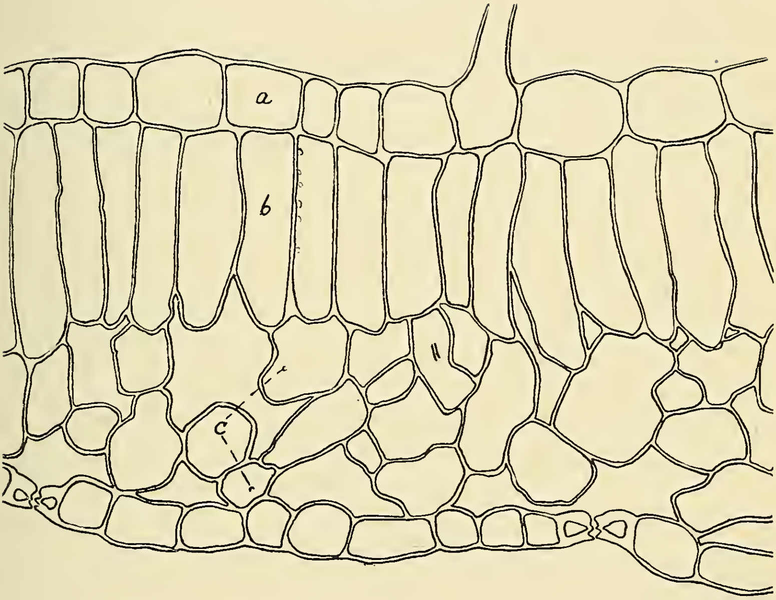
Mosaic disease on tobacco leaves. (1) Older leaves showing mottling. (2) Leaves showing marked distortion and tendency to string leaf (on right).

PLATE II.



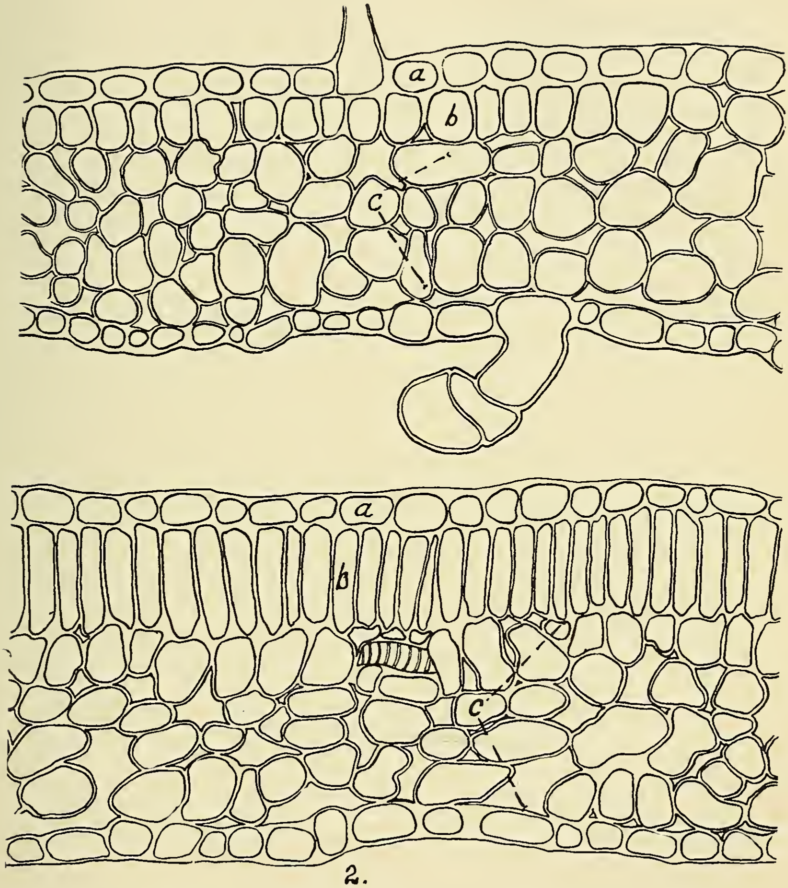
More or less indistinct types of mosaic disease, except (*a*), which is a young leaf with pronounced blisters.

PLATE III.



Section through normal tobacco leaf: (*a*) epidermis; (*b*) palisade cells; (*c*) parenchyma tissue.

PLATE IV.



Sections through mosaic-diseased leaves. (1) Light green area: (*a*) epidermis; (*b*) palisade cells; (*c*) parenchyma tissue. (2) Dark green area: (*a*) epidermis; (*b*) palisade cells; (*c*) parenchyma tissue.

ECONOMIC IMPORTANCE.

It is very difficult to estimate the loss to growers due to mosaic disease, as the prevalence in different localities varies greatly, as also does the intensity of the attack in different seasons. The damage resulting from mosaic disease is twofold: first the plants when severely attacked are smaller and the leaves poorer in quality; secondly, the buyer, if he sees much mosaic in a field, will invariably cut the price a few cents a pound, as the leaves affected do not in many cases make a valuable wrapper and are much poorer in quality. The writer has observed certain fields where the loss would run into hundreds of dollars from this cause alone. The amount of damage done by late mild attacks when the plants are maturing, or appearing on the sucker growth after topping, is practically negligible, and, so far as can be learned, does not in any way injure the commercial leaf. It is always well to clean off the diseased suckers, however, as they present a very ragged appearance, and might injure the sale of the crop to a certain extent. There is no question but that during certain seasons the loss due to mosaic is quite large, but an exact estimate of this loss is difficult to obtain, owing to the many other factors involved.

INFECTIOUS NATURE OF THE DISEASE.

That the mosaic disease is very infectious is well known, and a discussion of the detailed experiments on this point is not necessary. Experimentally it has been repeatedly shown that the juice from all parts of a diseased plant is capable of transmitting the disease, although it should be stated that the percentage of infection obtained from the root extract is considerably lower than that obtained from the leaves. A few of the results obtained are given in the following table, however: —

TABLE I. — *Infectivity of the Juice from Different Parts of Diseased Plants, August, 1909.*

PART OF DISEASED PLANT USED (PLANTS FROM FIELD).	Number of Healthy Seedlings inoculated.	Number of Plants Diseased Three Weeks after Inoculation.
Leaves showing disease,	10 (juice; needle pricks),	10
Control,	10 (distilled water; needle pricks),	-
Leaves showing disease,	10 (insertion of tissue into veins),	9
Control,	6 (insertion of healthy tissue into veins),	-
Basal leaves (not showing disease),	12 (juice; needle pricks),	10
Control,	5 (distilled water; needle pricks),	1
Roots,	21 (juice; needle pricks),	14
Control,	7 (distilled water; needle pricks),	-
Roots,	16 (insertion of tissue into veins),	6

Later experiments with the roots of other diseased plants gave similar low results.

It is a very easy matter to infect seedlings at the time of transplanting, and the writer has repeatedly seen many cases in the field which could only have been brought about by such infection. It is only necessary to get some of the juice from the diseased plant on to the hands to transmit the disease by handling healthy plants, the causal agent gaining entrance through the broken ends of roots, leaf hairs or broken and abraded leaf areas. In some of the experiments conducted relative to this point, a very high percentage of infection has been obtained. In one case where the juice from a diseased plant was very thoroughly rubbed on the hands, and 40 healthy seedlings immediately set, no care being used to guard against bruising the leaves, etc., 31 plants developed the disease in two weeks' time. In another experiment where 62 seedlings were subjected to the same treatment, 30 plants developed the disease; in still another, series of 28 seedlings, 21 developed the disease. Controls planted at the same time, handled with a hand rubbed with the juice of a healthy leaf developed the mosaic in only a few isolated cases. From the above it can easily be seen that great care should be exercised in the matter of handling the seedlings, especially diseased seedlings.

CONTAGIOUS NATURE OF THE DISEASE.

In spite of the fact that it is held by some investigators that the mosaic disease is contagious, the writer has never been able to satisfactorily demonstrate that it is. Under carefully controlled conditions in the greenhouse, guarding against accidental infection, it has been impossible to demonstrate the contagious nature of the disease. In isolated instances, indeed, apparent contagion has occurred, but it is believed that these cases were due to accidental infection, as the percentage was so low, — less than 2 per cent., — and under the conditions the plants were subjected to, such as contact, spraying of the juice on leaves, etc., the percentage should have been much higher if contagion was to be held responsible.

It is a fact that it is only necessary to break or rupture the trichomes or hairs on the leaf, subsequently spraying with diseased juice, to obtain infection, although this method does not give a very high percentage. It can easily be seen that such a rupture may be very easily brought about, and hence apparent contagion occur. As is stated elsewhere in this paper, insect and other carriers may also play a part in these so-called cases of contagion.

PATHOLOGICAL ANATOMY.

Leaves.

As might be supposed, there are great differences in structure between normal, healthy leaves and leaves affected with the mosaic disease. These differences are greatest, naturally, in badly diseased leaves. Woods [1] was one of the first to point out this fact, and his statements have been repeatedly verified by the writer. He stated that the light colored areas were not normal, and that "this difference consists in the fact that in badly diseased plants the palisade parenchyma of the light colored areas is not developed at all. All the tissue between the upper and lower epidermis consists of a spongy or respiratory parenchyma rather more closely packed than normal. In moderately diseased plants the palisade parenchyma of the light area is greatly modified. Normally the palisade parenchyma cells of a healthy plant are from four to six times as long as broad. In a moderately diseased plant, however, the cells are nearly as broad as they are long, or at most, not more than twice as long as broad. As a rule, the modified cells of the leaf pass abruptly into the normal cells of the green area."

From the above it can be seen that Woods was of the opinion that the light green areas were abnormal or diseased, and that the dark green areas were normal and healthy. The writer in his observations found this to be true in general, but occasionally the dark green areas showed a more closely packed parenchyma than in normal leaves, and *always the palisade layer was well developed* and approached the normal in character. The development or non-development of the palisade layer, as Woods hinted, is dependent on the degree of severity of the disease. The lighter the attack the less are the palisade cells and parenchyma tissue altered, and *vice-versa.* This the writer found to be true in so far as anatomical differences were concerned, but as will be noted later, the dark green, apparently normal, healthy tissue contained some of the infective agent of the disease.

The structure of the dark green areas varies only slightly from that of the normal leaf, with the few exceptions above noted, and may be considered normal in character. The writer has sectioned many leaves in all stages of disease, and these structural differences have always been found to occur in the manner above indicated. These differences in structure have been taken up more or less in detail, as some investigators have held, and still hold, that the dark green areas are the part diseased, and that the light green areas are normal, inasmuch as they approach the normal leaf in color in many cases, most probably basing their assumption on the fact that the dark areas form blister-like growths and are sometimes darker in color than normal leaves. No one recently appears to have investigated the structure of the dark and light areas carefully in the case of the tobacco, except Woods. It was to verify Woods' statements that the writer took up this phase of the matter, and mention will again be made of it in connection with the biochemistry of the leaf. There can be no doubt as to the correctness of Woods' contention that the light green areas are abnormal and diseased; but that the dark green areas are not diseased, at least in certain cases, cannot be so definitely stated. Their structure may be somewhat modified by the increased functioning thrown on the healthy cells. On the other hand, it is fallacious to state that the light green are the healthy, and the dark green are the diseased, portions of a leaf.

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[1] Woods, A. F.: Inhibiting Action of Oxidase on Diastase. Science, n. s., XI., No. 262, 17–19 (1900).

Plates III. and IV. show three cross sections from leaves, III. showing the cross section of a healthy leaf; IV., that of the light green area of a diseased leaf and of a dark green area of the same leaf. It will be noted that the palisade layer is practically suppressed in IV. (1), or the light green portion, while in IV. (2) the palisade layer approaches the normal in character except for a closer packing of cells in general. Milder cases of diseased leaves vary between these limits. These figures are from *camera lucida* drawings of material killed and fixed in medium chrom-acetic acid. In the material used the normal leaf section is somewhat thicker than those of the diseased leaf, but for comparative purposes is perfectly satisfactory.

Stems.

The anatomical differences in the leaves of healthy and diseased tobacco plants have been given in the preceding paragraphs, and as it was desired to carry the investigations further to cover the entire plant, repeated examinations were made of both cross sections and longi-sections of stems of plants in various stages of disease, and also of healthy, normal plants grown both in the field and greenhouse. It should be stated at this point that occasionally the writer has observed on the stems of some badly mosaicked plants a mottling, or, rather, a streaking of the stem, a portion of which would be darker green than the remainder, and this is without question a manifestation of the mosaic disease. Sections of such stems, however, showed absolutely no variation in structure from those of normal plants, and in no case, although the examinations covered an extended period of time, was it possible to show any structural difference between the stems of badly diseased mosaic plants and those of healthy plants of the same age. Examinations of the stem close to the terminal apex of the plant revealed the same conditions as those of other parts of the stem. No differences were observable except in the matter of size and arrangement of cells, such as would naturally be expected when we take into consideration the differences in size and development of the stem near the terminal apex and progressively towards the base.

Roots.

In the same manner roots of mosaicked and healthy plants were examined at various times under all conditions of growth and severity of disease, and in every case the root structure was found to be normal. Root tips from healthy and diseased plants showed absolutely no differences in structure. It might be anticipated that, as the disease first manifests itself in the dividing cells of the leaves, there might be a supplementary differentiation, so to speak, of the meristematic tissue at the growing point of the root, functioning co-ordinately with that of the aerial part of the plant. No such condition was observable, however, and, so far as the writer has been able to find, there is no manifestation of local cell disturbances in the root such as are found in the leaf tissue.

The causal agent of the disease, however, as has previously been noted, is without question present *in all parts of the plant,* and it should not be stated that it is confined to those parts which show structural variation.

Fungi and the Mosaic Disease.

Almost from the first it has been established that no fungi are associated with the cause and development of the mosaic disease of tobacco. In no case where careful work has been conducted under conditions eliminating the possibility of accidental infection has any fungus been found associated with the trouble. Cultures of fungi obtained occasionally from leaves have always been traceable to careless manipulation or external infection, and the fungus obtained failed to infect healthy plants, no matter what methods of inoculation were used.

The writer has occasionally obtained cultures on various media such as oat agar, tobacco leaf agar and prune agar, from the tissue of the so-called "rusted" spots which are sometimes a late manifestation of the last stages of the mosaic; but, as with previous investigators, it was found impossible to infect healthy plants from these cultures, either by needle pricks, spraying, or inserting the fungus into incisions in the leaf or stem.

These experiments with fungi were made merely to demonstrate to the writer's own satisfaction that they could not be the causative agents of the disease, as there might be a possibility that they were latent in the plant during the earlier stages of the disease and only developed superficially during the later stages.

According to Jenkins[1] and others these rusted spots which are sometimes observed are primarily caused by a drying out and disintegration of the cell tissue, which has been weakened by the disease and which thus forms a suitable medium, under favorable conditions, for the development of secondary fungi and micro-organisms. This view is also held by the writer as a result of observations extending over a series of years.

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[1] Jenkins, E. H.: Studies on the Tobacco Crop of Connecticut. Conn. Agr. Exp. Sta. Bul. No. 180, p. 56 (1914).

BACTERIA AND THE MOSAIC DISEASE.

Among the many theories advanced regarding the cause of the mosaic the chief one for some time, particularly among the earlier investigators, was that of bacterial infection either through the agency of infected soil or otherwise. Mayer,[1] in his rather extended study of the disease, came to the conclusion that it was caused by bacteria, but was unable to isolate the organism. Prilleux and Delacroix[2] claimed to have found an organism associated with the mosaicked leaves, but their descriptions leave one in doubt as to whether they were working with the true mosaic disease or not. It is very probable that they were dealing with another disease which occurs in France, but which is somewhat different from the mosaic disease. The next important work on the bacteria supposedly connected with this disease was done by Iwanowski.[3] He isolated several organisms from the juice of diseased leaves, and by reinoculation was able to cause infection, but only in a very small number of instances. This he explains by a probable attenuation of the organism when grown on artificial media. Hunger,[4] in a very critical review of the bacterial theory, stated that he was unable in any way to substantiate the findings of Iwanowski, and that although he observed certain bodies in the cells, he was not able to classify them as either bacteria or plasmodia, as they disappeared after heating with phenol chloral hydrate, while the rest of the cell contents were unaffected. More recently Allard[5] has advanced the opinion as a result of his investigations that the disease is parasitic in nature but does not attempt to discuss the character of the parasite, and apparently has made little attempt to demonstrate anatomically the presence or absence of bacteria. Hunger's work is probably the most satisfactory of its kind along this line.

The writer has made examinations of diseased plants, sectioning leaves, stems and even the roots, but has never been able satisfactorily to demonstrate the presence of bacteria in the tissues. In this work a variety of stains were used, chief of which, however, were Ziehl's carbol fuchsin and Heidenhain's iron hæmotoxylin.

It is to be noted in this connection that all investigators have apparently confined their studies to the leaves or part of the plant in which the disease showed itself, and very few attempts, if any, have been made to study the question of the possible presence of bacteria in tissue far removed from the diseased portions. In view of the fact that the juice from all parts of a diseased plant will cause infection, it would be natural to suppose that if bacteria were the causal agent, it should be possible to demonstrate their presence in the different parts of a diseased plant. This has never been done, and in the writer's study of the anatomy of diseased plants it has never been possible to demonstrate the presence of bacteria in the different tissues. The writer has many times attempted to obtain cultures of bacteria from diseased tissue, and in some cases cultures of organisms were obtained on various media, but they proved in every case to be secondary in character, and were not capable of reproducing the disease. In the light of all later investigations the evidence points overwhelmingly to the absence of bacteria, in the present-day sense of the term, as the causal agent of the disease.

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[1] Mayer, A.: Over de in Nederland dikwijk voorkomende Mozaikziekte der Tabak. Land. Tijdschr. (1885).

[2] Prilleux, E. E. and Delacroix, G.: Maladies bacillaires de divers végétaux. Compt. Rend. Acad. Sci. Paris, 118: 668-671 (1894).

[3] Iwanowski, D.: Über die Mosaikkrankheit der Tabakspflanze, Zeit. f. Pflanzenkrank, 13: 1-41, pl. 1-3 (1903).

[4] Hunger, F. W. T.: Untersuchungen und Betrachtungen uber die Mosaikkrankheit der Tabakspflanze. Zeit. f. Pflanzenkrank, 15: 257-311 (1905).

[5] Allard, H. A.: Mosaic Disease of Tobacco. U. S. D. A., Bur. Plant Ind. Bul. No. 40 (1914).

DISSEMINATION AGENTS.

Insects.

The fact that many fungous and bacterial diseases are often transmitted by insects, as well as other agents, has been long known and thoroughly established, but until Allard (*loc. cit.*) called attention to the fact that the mosaic disease could be carried by aphids, and one in particular (*Macrosiphum tobaci* Perg.), nothing had been published on this phase of the matter. Allard in well-controlled experiments demonstrated beyond a reasonable doubt that the disease was so communicated. Clinton (*loc. cit.*) made a few observations on the infection of healthy plants by the tobacco horn worms which had been feeding on diseased leaves, but was unable to demonstrate that the disease could be so transmitted either by the excreta ejected by the worm or by its biting and feeding on the healthy plants. His results were negative in the few experiments made. Observations made in the field during the progress of the writer's work have not shown conclusively that the disease is communicated by biting insects, such as the tobacco horn worm, grasshoppers and a small black flea beetle of more or less common occurrence in our fields.

Occasionally aphids have been found infesting the leaves of tobacco in our fields, but so far as could be judged were present in too small numbers to be active agents in transmitting the trouble. As a rule, comparatively few aphid infestations are found in our tobacco fields.

In the greenhouse during several winters tobacco plants grown in benches were infested with white fly, and it was at first feared that they might carry the infection from diseased to healthy plants in the same benches. This, however, was not the case, and it has never been possible to demonstrate positively that the white fly is an active agent in the spread of the disease. This insect is, of course, of rare occurrence in our fields, but may possibly do damage in the south. It apparently feeds and breeds freely under greenhouse conditions on the underside of the leaves.

In order to ascertain more definitely the possibility of infection by these insects, adult white flies from badly mosaicked leaves were carefully removed and placed on the underside of the leaves of tobacco plants, enclosed in a small cloth-covered cage, and were allowed to remain on the tobacco leaves of the plants in these cages for four days. After this length of time the plants were removed from the cages and placed on a bench at some distance from those containing mosaicked plants badly infested with white fly. On none of the plants did mosaic develop. The plants were later placed in close juxtaposition to those in the original benches, which, as indicated, were at this time heavily infested with the white fly and badly mosaicked, but although the plants remained until maturity, no cases of mosaic developed on them in spite of a heavy infestation of white fly.

The writer's observations on the activities of aphids as carriers of infection have not been so extensive as in the case of the white fly, as only minor infestations of the former occurred in the greenhouses; and the indications pointed to the fact that, although there were a certain number of aphids present on the leaves of both healthy and diseased plants, so far as was observable no cases of infection from this source arose, as the mosaic developed only on an average of 1 case out of 30, except on the plants which were artificially inoculated with the juice from diseased leaves. It should be stated, however, that aphids present in the greenhouse were not of the same species as that under consideration by Allard, and there is no reason to doubt the accuracy of his observations on the species *tabaci* Perg.

The question of insects as carriers of the mosaic disease as well as of many other diseases is still open to discussion; and it may be that in the case of the mosaic a very heavy infestation of aphids is necessary to bring about a successful infection of healthy plants, as the amount of active infective material carried by such insects would in any case be very small, and accumulative effects of the activities of several insects might be necessary to introduce a sufficient amount of the active principle to transmit the disease.

Workmen.

It has been shown that the disease is highly infectious and it has also been proved repeatedly by many investigators that it is very easy to transmit the disease to healthy plants at the time of transplanting. A workman handling diseased seedlings, and subsequently healthy ones, will very often infect them. Several instances of this have come to the writer's attention, every other plant for some distance in a row developing mosaic within a month after transplanting. The same condition has also been observed by Clinton (*loc. cit.*) in Connecticut, and can only be explained by the fact that the workman's hands were infected through handling a diseased plant, and the infection then transmitted to healthy ones, the causal agent being introduced through broken tissue of the leaves or roots of the seedlings. This method of transmission is particularly striking in the above case, as the same individual plants every other plant in a row when working the ordinary planter. Of course, there have been many cases where every plant for some distance in a row has developed mosaic, but this might be explained if it is assumed that *both* workmen had handled diseased seedlings, or if a number of plants in the lot were diseased. In time, the causal agent becomes so attenuated that infection ceases, and the remainder of the row remains healthy. Experimentally, this method of transmission has also been shown to be possible, and a high percentage of infection has been obtained. In one experiment, after thoroughly rubbing the hands with the tissue of a diseased plant, and then pulling and transplanting healthy seedlings, over 80 per cent. of the transplants became mosaicked within a month. Only a relatively small number of seedlings in this instance were treated in this way, however, the total being 28, of which 24 developed mosaic symptoms within three weeks.

Another manner of transmission is by cultivation. If some of the sap from a diseased plant comes in contact with the tools, etc., employed, there is a possibility that the infection might be carried to healthy plants by this means, but the percentage of infection of this character is probably very low in actual field practice.

The workmen when budding and topping are very often carriers of infection, as they are not as a rule careful to leave untouched the plants showing mosaic symptoms but take the plants as they come, and thus spread the disease to many healthy plants. This method of dissemination has been very often observed, and perhaps is the most fruitful source of infection in the field. The subsequent new growth will almost invariably be mosaic in character, as will also the suckers developing later. The amount of damage to the marketable leaves, however, providing the suckers are removed, is very slight, if any, and cannot be said to injure the leaf in any way, at least in so far as our observations bear on this point. If the suckers are left, however, the plants present a ragged appearance, and the mosaic on the suckers is quite noticeable, and might injure the sale of the crop at the price it ought to command.

Seed.

The causal agent is *not* carried by the seed, and seed from mosaic plants has never produced a larger percentage of mosaicked seedlings than seed collected from healthy plants, when germinated and grown under the same conditions. It is difficult to conceive of this, as it has been shown by Allard (*loc. cit.*) that the tissues closely enveloping the seed in the pod are capable of causing infection; but the writer has saved seed from badly mosaicked plants for three successive years, and the seedlings from such seed showed no signs of the disease, unless infection was produced artificially through some external agency.

It should be pointed out, however, that there is the possibility that the vigor of the seed from mosaicked plants may be less than that from healthy ones, and consequently the plants developed from such seeds, being weaker, might be more susceptible to the factors active in the production of mosaic symptoms. It is impossible to make a definite statement on this point, however, as the writer has not been able to gather sufficient data over a series of years to prove or disprove it.

FERTILIZATION IN RELATION TO MOSAIC DISEASE.

It has been repeatedly shown by many investigators (see historical summary) that a lack of plant food alone will not suffice to produce the mosaic disease, and the writer has also, in connection with the tomato, shown that an *excess* of nitrogen, potash, phosphoric acid and lime will not produce nor intensify the disease.[1]

The same has been found to be true for tobacco. In our experiments on tobacco, the method made use of was to add to each pot the proper amount of a complete tobacco fertilizer (in this case applied at the rate of 3,000 pounds per acre), and then to add an additional amount of nitrogen, potash and phosphoric acid in quickly available forms, equal to that already present. No mosaic was produced in any case, although where the amount of nitrogen was trebled a rather peculiar malformation of the leaves was observed which at first sight might have been mistaken for mosaic symptoms. All inoculations failed to take, however, and the trouble therefore could not have been the true mosaic.

It has been held that liming would lessen the prevalence of the disease, but the writer's observations and experiments do not bear out this statement. Under field conditions this may be the case in certain seasons, but continued observations from year to year on heavily limed areas show no appreciable lessening of the number of mosaicked plants. Seedlings and plants grown in the greenhouse in soil known to be heavily infected indicated the same results, as also did the work on new soil with mosaicked seedlings. Here lime was applied in varying amounts at the rate of from 500 to 6,000 pounds per acre. No appreciable effect on the mosaic disease was observable. The results obtained are given in the following tables: —

TABLE II. — *Effect of Liming on Mosaic.*

[New soil, lime, mosaicked seedlings.]

LIME (POUNDS PER ACRE).	New Soil in Pots (Number planted with Mosaicked Seedlings).	Number of Plants showing Recovery One Month after Planting.
500,	40	-
1,000,	28	-
2,000,	34	-
4,000,	12	-
6,000,	10	-
No lime (check),	5	-

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[1] Twentieth Annual Report, Mass. Agr. Exp. Sta. (1908), p. 140.

The lime was applied to this new soil, in the different amounts indicated, one week previous to the setting of the plants.

No appreciable differences were observable in the subsequent growth as regards intensity of mosaic symptoms, all the plants being comparatively evenly mosaicked. There was not a single case of recovery.

TABLE III. — *Effect of Liming on Mosaic.*

[Infected seed bed soil, lime, seed.]

LIME (POUNDS PER ACRE).	Per Cent Infection (Seedlings Twelve Weeks Old).
500,	12.0
1,000,	18.4
2,000,	9.8
4,000,	21.0
6,000,	8.6
No lime (check),	13.7

The lime was here applied to a soil which was heavily infected, and the seed sowed very thinly in the flats containing the various amounts of lime and soil. The seedlings were allowed to grow in the flats until they were counted. They were naturally crowded somewhat, but were free from insects during the period of growth. It is possible that some infection may have occurred, however, but there are very strong indications that liming had no beneficial action in lessening the disease. As the results are so variable the matter cannot be considered as absolutely settled, but certainly no consistently favorable results were obtained in this experiment from the use of lime.

EFFECT OF COLORED LIGHT ON MOSAIC DISEASE.

In connection with work on the mosaic disease of tobacco it had long been noted, in that section of the Connecticut Valley where the crop was grown under shade, that the plants appeared in general to be much less affected with the mosaic disease than were those grown in the open. This fact has already been noted by Sturgis[1] in Connecticut. Investigations were outlined, in conjunction with other work on this disease already under way, relative to a study of the effects of various light conditions on the intensification or reduction of the disease. While the writer's preliminary work was in progress, Lodewijks[2] published a paper on the effects of colored light on mosaic-diseased plants, and as a result of his experiments stated that a cure was effected by blue light, red light diminished the disease, and suffused light checked it somewhat. In brief, his methods of experimentation and conclusion were as follows: —

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[1] Sturgis, W. C.: On the Effects, on Tobacco, of Shading and the Application of Lime. Conn. Agr. Exp. Sta. Ann. Rept., 23, 252-261 (1899).

[2] Lodewijks, J. A., Jr.: Zur Mosaikkrankheit des Tabaks. Rec. Trav. Neerlandais, Vol. 7, 107-129 (1910).

The diseased leaves of a plant were covered with a cloth hood of the desired color, of a sufficient size to allow ample room for growth. The apparently healthy basal leaves were left uncovered and exposed to the normal daylight. After a time the hoods were removed, and it was found that in the case of the plants exposed under the blue hood a cure was effected; those exposed under a red hood showed a diminution in the severity of the disease; and in the case of plants exposed to the suffused light alone the disease was somewhat checked. The cloth used for the red and blue hoods was a rather coarse cotton material similar to that used for making flags.

Several investigators had noted the apparent beneficial effects resulting from growing diseased plants in suffused light, but Lodewijks was the first to really study the effects produced by colored light, although Bauer appears to have made some observations on this point. As in no case could the writer find that Lodewijks in his work had reinoculated from the apparently cured plants to healthy ones, to prove the presence or absence of the causal agent, and as it is often present and active in apparently healthy leaves of diseased plants, as has been shown many times, it was thought necessary to settle the point as to the presence or absence of the causal agent in plants treated as in Lodewijks' work.

Method. — The method of treatment of diseased plants was in every way similar to that employed by Lodewijks as to texture of cloth, methods of covering the plants, etc. The cloth covers were held away from the plant by means of wire hoops, and the cloth was tied around the stem of the plant below the diseased leaves. Plate V. shows a hood in place over a field-grown plant, and gives a clear idea of the arrangement of the hoops, etc.

The cloth used was a coarse grade of cotton, and the colors were cadmium orange, ox-blood red and indulin blue.[1]

Plants showing well-developed symptoms of the mosaic disease were selected for the experiment, none of which had less than four characteristically diseased leaves, the lower remaining leaves apparently healthy. The hoods were placed over the diseased leaves as above noted, and left on for the required time, in most of the experiments twenty to thirty days. At the end of this period the hoods were removed and the plants carefully examined for *visible* symptoms of the disease. Two leaves from the upper (*i.e.*, the part under the hood) portion of the plant were removed under absolutely aseptic conditions, the juice expressed and healthy plants inoculated therewith by means of glass capillaries inserted just below the terminal leaflets. Control inoculations with distilled water and boiled juice were also made at the same time. The plants, after the

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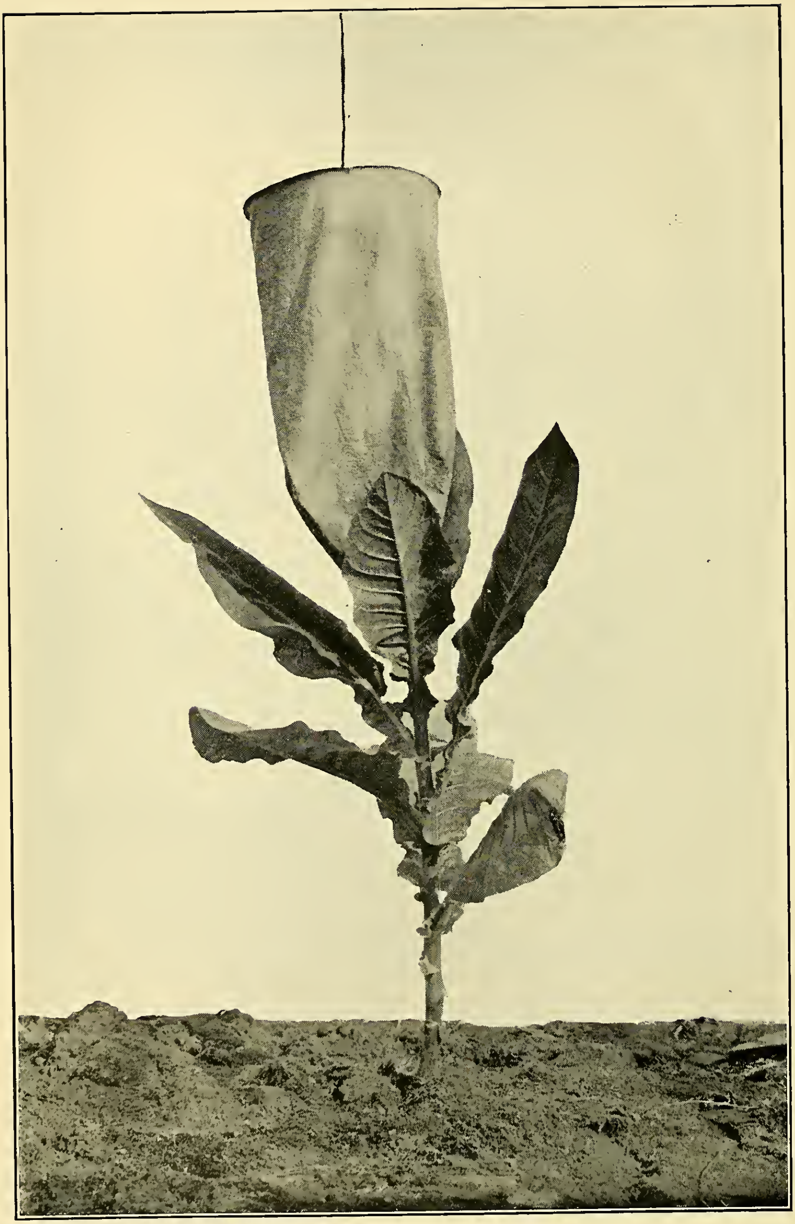
[1] Ridgway, Robert: Color Standards and Color Nomenclature. Washington, D. C. (1912).

PLATE V.



Effect of colored light on mosaic disease; showing method of attaching hoods over leaves.

removal of the leaves above mentioned, were allowed to grow to maturity under normal light conditions.

Most of the experiments were carried on in the greenhouse, where temperature and other conditions were under more direct control than in the field, although field experiments later repeated gave the same results, but, of course, in this case there was a greater chance of subsequent infection through careless handling, insect attacks, etc. In the following paragraphs are tabulated the results of a typical series of experiments relative to the effects of light on mosaicked plants.

Experimental Data.

Red Cloth. — Three plants were covered with the red cloth hoods for twenty days. The covers were then removed, and in all cases visible symptoms of the disease were still present, although the color variation between light and dark green areas was not so marked as at the beginning of the experiment. All the new growth, in addition to the leaves diseased at the time the hoods were put on, also showed the mottling distinctly. A week after the hoods were removed all the plants still showed the disease in undiminished severity.

Healthy plants inoculated with the juice from the leaves confined under the hood became diseased in from nine to eighteen days' time. Controls inoculated in the same manner with boiled juice from the same leaves, and with distilled sterile water, remained with very few exceptions healthy. Table IV. gives the results of the inoculation experiments in one series.

TABLE IV. — *Result of Inoculation with Juice from Plants grown under Red Hoods.*

PLANT NO.	Number of Healthy Plants Inoculated with Juice from Leaves of Treated Plant.	Number of Inoculated Plants showing Mosaic at the End of Eighteen Days.
A-1,	6	6
B-1,	7	6
C-1,	4	4

Controls inoculated with boiled juice, 10; diseased in eighteen days, 1.
Controls inoculated with distilled, sterile water, 10; diseased in eighteen days, 0.

From the above results it may be seen that there was a diminution in the color variation in diseased leaves; it was not of a permanent character, the plants all showing the disease in undiminished severity again after a short exposure to normal daylight. The causal agent of the disease was still highly infectious.

In a second series the hoods were allowed to remain over the plants for thirty days, as it was thought that a twenty-day exposure might have been too short, but no appreciable variation in the results was obtained as a result of the longer treatment.

Orange Cloth. — In this series two plants were covered with orange hoods for a period of thirty days. On removing the covers it was found that the visible symptoms of the disease were, if anything, intensified. The growth was somewhat more spindling, the leaves narrower, and the light and dark green areas very clearly defined. Infection was produced from both plants by inoculation into healthy plants. The causal agent was very active and highly infectious.

Blue Cloth. — The diseased parts of three plants were covered with blue cloth hoods, as in the preceding experiments, for a period of twenty-five days. The covers were then removed and a careful examination of the leaves made. On plants A-2 and B-2 no visible symptoms of the mosaic disease could be observed, although a slight tendency towards curling was noticeable on a few of the leaves. The leaves were all uniformly light green in color, and aside from this, appeared normal. Plant C-2, however, showed on two leaves a slight mottling. Two weeks after the hoods were removed, plants A-2 and B-2 did not show any marked symptoms of the mosaic disease other than a faint mottling of a few leaves, not sufficient, however, to seriously injure the leaf. Plant C-2 developed mosaic again in the same length of time, but not as seriously as before the treatment. It may be that the mottling on A-2 and B-2 was due to the maturing of the plant, although this mottling is usually distinctive enough to be readily differentiated from that caused by the mosaic disease.

Healthy plants inoculated with the juice of leaves from plants A-2, B-2 and C-2 contracted the disease almost without exception. Controls inoculated with boiled juice failed to develop the disease. Table V gives the results of the inoculations.

TABLE V. — *Results of Inoculations with Juice from Plants grown under Blue Hoods.*

PLANT NO.	Number of Healthy Plants Inoculated with Juice from Leaves of Treated Plant.	Number of Inoculated Plants showing Mosaic at End of Eighteen Days.
A-2,	8	5
B-2,	4	4
C-2,	10	9

Controls inoculated with boiled juice, 6; diseased in eighteen days, 0.
Controls inoculated with sterile distilled water, 6; diseased in eighteen days, 1.

The above results show that when blue light is used there is a suppression of leaf color variation more or less permanent in character, the treated plants, with one exception, showing no typical symptoms of the disease for at least two weeks subsequent to the removal of the hoods. It cannot be said, however, that the disease was controlled, as inoculation of healthy plants with the juice from these leaves produced the disease in nearly every case.

The causal agent of the disease was still very active in the *apparently normal fully recovered leaves*, and was highly infectious.

Discussion of Results. — The results of these experiments do not agree entirely with those obtained by Lodewijks, particularly in the case of action of the blue light, inasmuch as the plants covered with the blue hoods, although showing an *apparent* recovery from the mosaic, still contained the causal agent of the disease, and by inoculation with the juice expressed from these plants into healthy plants the disease was again produced in practically all cases. It should be noted that the visible symptoms of the disease were suppressed, the reason for which may be as Allard (*loc. cit.*) suggests in his work on the mosaic disease of tobacco. He states, with respect to Lodewijks' observations, "If the malady in question was true infectious mosaic disease, one is inclined to believe that covering the young plants temporarily reduced the color contrasts of the mottled areas. These changes may have led Lodewijks to conclude that a partial or a complete cure had been effected in his experiments."

It might be inferred from the above that on the removal of the hoods exposing the plants to normal daylight, they would soon regain the color contrast, but this is not entirely so in the case of the blue light, as has been shown. The apparent recovery, therefore, is not entirely the result of a suppression of color contrast due to the action of blue light on the leaves as suggested by Allard, but is undoubtedly so in part.

It is evident that the treatment of plants as above recorded does not destroy the causal agent of the mosaic disease, whatever may be its character, the treated leaves apparently still containing the causal agent, very probably in the same manner as do the parts of a plant which do not show visible symptoms of the disease, as the stem, lower leaves, roots, etc., the juice of which is often highly infectious. It would appear from the results that the new terminal growth subsequent to the removal of the hoods would develop the trouble, and this was the case in plant C-2, but not apparently so with plants A-2 and B-2. Lodewijks' opinion, therefore, that in the plant a "virus" and "anti-virus" are present, and that certain abnormal conditions cause the "virus" to be produced in excess, bringing about a mosaicked appearance, while if the "anti-virus" is produced in excess, immunity is secured, will hardly hold, as it is clearly shown that even after apparent cure the causal agent is present and active.

It is significant to note that under the influence of blue light both assimilation and starch formation are decreased, thus bringing about a partial starvation, as it were, not, however, serious enough to reduce greatly the total starch formation and assimilation of the whole plant; while at the same time the chlorophyll production is very little changed if a comparison of the color of the normal and treated leaves can be taken as a basis of such a comparison. This latter fact has already been noted by Lodewijks in his work on the disease.

It is, therefore, indicated by the results obtained in the preceding experiments that the different colors have little or no effect on the causal agent of the disease, but in the case of the blue there is a strong depression of the macroscopic symptoms of the disease.

Biochemical Studies.

Enzyme Activities in Healthy and Diseased Plants.

The study of enzymes in relation to diseases, particularly those of a so-called physiological nature has not been extensively gone into as yet by investigators, but it is believed that a study of their activities and reactions should be made, not only in the case of physiological troubles, but also those caused by fungi and bacteria, as it is the writer's firm belief that the activities of a large number of the fungi, and their effects on the respective hosts, are in a great measure due to the action of either exoenzymes or endoenzymes produced by the fungi concerned. There is a possibility that the future may show a great advance in the study of host resistance, etc., when the conditions under which enzyme activity in fungi and bacteria takes place are better known, and plants may possibly be bred to a condition of producing either a sap in which these activities cannot take place, or will produce anti-enzymes which will inhibit the activities of the enzymes contained in the respective fungi.

Although many have made a study of this disease, very few have concerned themselves with the question of the enzyme activities; among the first to make mention of this phase of the question was Woods (*loc. cit.*), who found that the enzymes designated as peroxidases were at least diffusable, and occurred apparently in larger amount in diseased leaves than in healthy ones; also that their action was twice as strong in the light green areas as in the darker portions of the leaf. Koning (*loc. cit.*), as a result of his investigations, came to the conclusion that the disease was caused by a certain enzyme, which he stated to be oxidase, and the action of which he described. He believed that it was formed in the plant under certain conditions. Heintzel[1] also found oxidizing enzymes present which were more active, if not present in greater amounts, in diseased plants than in the normal plants. Woods later (1902), in his work on the mosaic disease, verified his former observation, and stated further that the diastase activity was much inhibited in the case of diseased plants. He attributed the lessened diastase activity to the presence of excessive amounts of oxidizing enzymes, and showed experimentally that diastatic action is inhibited by the presence of oxidizing enzymes. This is the only work that has been accomplished up to the present time, so far as relates to a study of the enzyme activities involved in this disease. Only two enzymes have been considered, namely, the oxidase and diastase, and it should be stated that in the light of later developments in the determination and estimation of enzyme preparations and activities the results obtained in some cases might well be open to some criticism.

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[1] Heintzel, K.: Contagiose Pflanzenkrankheiten ohne Microben mit besonderer Berücksichtigung der Mosaikkrankheit der Tabaksblätter. Erlangen, 46 p., 1 pl. (Inaugural Dissertation) (1900).

Loew,[1] while working with tobacco, discovered the presence of an enzyme which he called catalase, but he made no observations relative to its activities in the case of mosaic-diseased plants. The results of the writer's studies on enzyme activities of healthy and mosaic plants are detailed below.

Method. — In the experiments here detailed the enzymes under discussion were studied, in so far as was possible, (1) with regard to their presence or absence in (*a*) leaves, (*b*) stems and (*c*) roots of healthy and diseased plants (this was considered necessary, as it has been found that, irrespective of the parts showing visible symptoms of the disease, the sap from all other parts also is capable of transmitting the trouble); (2) with regard to the age of the plant; (3) with regard to the growth of the plant under different conditions. These will be discussed in detail under their respective sections.

The methods employed for the estimation were for the most part those which by experience have been found satisfactory, and in the main give quantitative results; in some cases the results are more or less qualitative in nature, owing to our present insufficient knowledge of the methods of isolation and action of the enzyme involved.

It should be stated that plants used in the experiments were both field and greenhouse grown, but no essential differences in results were obtained from the two series. The individual experiments will not be given in detail, but as the determinations of any given series were made in every case in the same manner, only average results with the maximum and minimum readings will be given. The experiments are, however, described in sufficient detail to enable those interested to follow the methods employed closely enough to check up the work of the writer.

Catalase (*leaves*). — A comparison was made of the catalase activity of healthy and diseased leaves, as it had been noted as early as 1908 by the writer that there was apparently a great difference between the catalase activity of healthy and mosaic-diseased tomato leaves, and later the same was found to be true in the case of tobacco. At that time only rough determinations were made, but since then the writer has made hundreds of determinations, the results of which have borne out the observations made then, and indisputably established the fact that there is a wide difference in the catalase activity of healthy and diseased leaves.

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[1] Loew, O.: Catalase: A New Enzyme of General Occurrence, with Special Reference to the Tobacco Plant. U. S. D. A., Bur. Plant Ind., Bul. No. 68 (1901).

In all the experiments freshly collected material was used, and the determinations made almost immediately after collection. The usual procedure was as follows: —

A weighed amount of leaf was ground thoroughly with a weighed amount of acid-washed sand and a certain volume of double distilled water, and the whole washed into the apparatus with sufficient double distilled water to bring the volume up to the standard volume used in the particular series in question. This, of course, gave to each flask a standard constant dilution value. To this mixture was then added a like volume of 1 per cent. solution of Merck's perhydrol, thus making the H_2O_2 concentration of the total mixture .5 per cent. The amount of oxygen liberated in ten minutes was arbitrarily taken as the measure of enzyme activity. Several different forms of apparatus were used, but for large amounts of leaf any ordinary water displacement method was found to be very satisfactory. (Care should be exercised where this mode of analysis is used, to take into account the absorption of oxygen by the water.) In making determinations where the amount of material was very small, the apparatus designed by Lohnis for use in milk examinations was found to be more convenient. Practically all determinations were made at temperatures ranging from 17° to 23° C. The action of the catalase is much accelerated by shaking, as pointed out by Loew, and each test was shaken under exactly similar conditions in all the determinations made. It was found necessary to use this method for the determination of the catalase activity, as any method involving titration, such as the permanganate method, was unsatisfactory, due to the reaction of certain constituents in the tissue with the reagents.

Table VI. shows the relative amounts of oxygen developed in normal tobacco leaves, and it is to be noted that the catalase of the dark green leaves was much more active than that of the light green leaves. This was found to hold true, to a certain extent, for light and dark green leaves even on the same plant. The basal leaves of older plants, which in some cases were almost mature, and of a lighter color than the middle and upper leaves, developed in every case relatively less oxygen. This was particularly true in the case of Havana tobacco. Broadleaf did not show such a wide divergence, but it should also be stated that in the Broadleaf plants employed in the determinations the basal leaves did not show any great color difference.

As will be noted, some of these experiments were made with plants grown under field conditions, but a greater number were made with plants grown in the greenhouse, under control conditions.

TABLE VI. — *Catalase Activity in Healthy Leaves.*

Weight leaf used=3 grams. Time of action=10 minutes. Temperature=17 to 23° C. Vol. of leaf+H_2O=100 c. c. Vol. 1 per cent. H_2O_2 added=100 c. c. g=greenhouse. f=field.]

Series.	VARIETY.	AMOUNT OF OXYGEN DEVELOPED (CUBIC CENTIMETERS).			Color of Leaf.	Number of Determinations.	Age of Plant.
		Maximum.	Minimum.	Average.			
A	Havana (g),	139.0	97.0	119.8	Dark,	40	Half grown.
B	Havana (g),	103.0	48.0	56.0	Light (basal),	26	Nearly mature.
C	Havana (g),	94.0	61.5	77.5	Light (whole plant light),	7	Half grown.
D	Broadleaf (g),	126.4	101.0	113.7	Dark,	3	Half grown.
E	Broadleaf (g),	154.0	119.5	126.3	Dark,	11	Nearly mature.
F	Broadleaf (g),	106.7	78.2	93.4	Light (basal leaves),	5	Nearly mature.
G	Havana (f),	176.0	115.5	124.8	Dark,	19	Half grown.
H	Havana (f),	147.6	93.1	100.2	Dark,	14	Nearly mature.
I	Havana (f),	121.0	72.9	91.0	Light,	6	Half grown.

These results show that the catalase activity varies somewhat even in healthy plants, dependent upon age and also, apparently, on the general condition of the plant. It shows clearly, also, that in plants of approximately the same age the catalase activity varies somewhat between plants with dark green leaves and those with light green leaves.

Even on the same plant this holds true, as can be seen from the results tabulated below.

TABLE VII. — *Catalase Activity of Light and Dark Leaves from Same Plant.*

[Plants nearly mature; procedure as in Table VI.]

PLANT NO.	Number of Determinations.	Light Leaves, Cubic Centimeters of Oxygen developed (Average).	Dark Leaves, Cubic Centimeters of Oxygen developed (Average).
B_1, ...	4	51.8	119.8
X_{11}, ...	3	62.0	125.5
104, ...	3	71.4	93.7
A_{17}, ...	6	58.1	79.3

An examination and determination of the catalase activity in diseased leaves shows that the amount of oxygen developed is relatively much less than in the case of healthy leaves. In the table below are given some of the results obtained from diseased leaves. In these experiments the leaf tissue was used without reference to the light and dark areas of the individual leaf. It is significant that the activity is very much less than in healthy leaves. All the plants used in this series were badly diseased. It should be stated that in apparently mild cases of the disease the variation from the normal catalase content was not so great. The results shown here can hardly be compared with those given in Table VII., as the plants were not in some cases of the same age, nor were they grown at the same time.

TABLE VIII. — *Catalase Activity in Diseased Leaves.*

[Plants badly diseased; procedure as in Table VI.]

PLANT NO.	Number of Determinations.	Cubic Centimeters of Oxygen developed (Average).
P_6, ...	8	47.2
R, ...	6	32.8
3_a, ...	9	54.5
A_x, ...	11	69.6
Total, ...	34	51.0

In the next table will be found a comparison of the results of catalase activity in healthy and diseased leaves from plants grown at the same time and under identical conditions. The plants were inoculated artificially in as uniform a manner as possible.

TABLE IX. — *Catalase Activity in Leaves of Healthy and Diseased Plants of Same Age.*

[Procedure as in Table VI.]

LEAVES.	Number of Determinations.	Cubic Centimeters of Oxygen developed (Average).
Diseased,	10	52.3
Healthy,	10	119.0

The values here obtained simply substantiate those given in preceding tables, but in addition allow of a direct comparison.

The leaf tissue was used in the preceding experiments without regard to the light and dark green patches on the individual leaf.

It was thought that an examination of the light and dark green areas of individual leaves of mosaicked plants might give a clue as to whether the activities of the catalase were inhibited in one or both of these areas in comparison with a leaf from a healthy plant of approximately the same age and color.

It was found that the catalase activity of the dark green areas approached that of the normal leaf of the same color, while the catalase activity of the light green areas was much below normal, even in the case of a light green normal leaf being used for comparison. The values obtained are given in Table X.

TABLE X. — *Catalase Activity in Diseased Leaves.*

[Comparison of light and dark green areas; procedure as in Table VI.]

SERIES.	Number of Determinations.	CUBIC CENTIMETERS OF OXYGEN DEVELOPED (AVERAGE).	
		Light.	Dark.
X,	4	42.1	73.6
0,	3	37.0	95.4
21,	8	54.3	103.0

Diastase. — It is a well-known fact that diastase is intimately connected with metabolism in the leaf in practically all chlorophyll-bearing plants, as well as in many of the fungi, and the relations of the activities of diastase in the mosaic disease are of rather significant import, as can be easily shown. It was pointed out several years ago by Woods (*loc. cit.*) that the action of oxidizing enzymes when present in solutions containing diastase tended greatly, under ordinary conditions, to inhibit the activities of the diastase. Turning more particularly to the mosaic disease, he made the observation that in the cells of the light green areas, although they formed starch practically in a normal manner, so far as could be observed the starch was not translocated, and that in the morning there was practically as much starch present as at night, which is not the case in a normally functioning leaf. In this case it was found that practically all the starch disappeared in the night and was translocated.

Recently there has been more or less contention as to the exact method of action of diastase on starch, and within the last two or three years important investigations have resulted in the opinion, substantiated more or less in detail, that the diastase of the older writers is not one enzyme alone, but is made up of at least two components. The first of these breaks down the starches into, or as far as, the erythro-dextrine and achro-dextrine stage, the second component taking up the action from this point and completely hydrolizing the starch to the sugar compounds which are found to be present, as the next step in the process of metabolism.

It was in the light of these investigations that the writer took up the question of the diastase activity in the mosaic disease, and it was found to be less active in the leaves which showed severe symptoms of the disease than in those which showed only a slight trace. There was, however, apparently a greater or less breaking down of the starch in all the leaves examined, so far as could be determined by the colorimetric methods, which, although not altogether satisfactory, may be relied upon as much as any of the present-known methods of determination. At the morning examinations the starch did not in some cases take on the color of the normal starch in the healthy leaves, but was accompanied by a yellow brown to a reddish or violet coloration, dependent somewhat on the strength of the indicator used. The strength of the iodine solution used in this case was a fiftieth normal iodine-potassium iodide solution. This reaction would indicate that the starch to a certain extent had been acted upon at least partially by the diastatic enzymes, and would indicate also that it was possibly the first of the components above mentioned which was more active, and that the second was more or less inhibited in its action. In the normal leaf, of course, there was a certain amount of starch present indicated by the blue coloration of the granules. The amount was slight, however, compared to that in the diseased leaves, and in no case was there any of the brown or violet color, almost complete hydrolysis having apparently taken place very rapidly. This would indicate, as pointed out by Woods, that the oxidizing enzymes, of which we will make mention, and which are present in excessively large amounts in the diseased areas of the leaf, do play an important rôle in the controlling or inhibiting of the activities of the diastatic enzymes, but not on the diastase in the old conception of the term. Rather it might be said the action is on the primary enzyme concerned in diastatic activity, if the newer concept of diastatic activity above advanced is true, as it would seem to be from the unpublished investigations of Roessler of the University of Prague, who was able to separate by salting out from a very carefully prepared solution of the ordinary diastase at least two components having the respective actions above mentioned. In no case, as indicated by the color reaction obtained, did we get a complete hydrolysis of a large amount of starch, the process only being carried on, apparently, as has been indicated, — as far as the erythro-dextrine and achro-dextrine stage. It was attempted in our experiments to isolate or rather separate out diastase in a more or less pure form from the leaves of healthy and diseased plants, and although certain results were obtained, it was rather a difficult matter, as in the writer's experience it has been found that diastase is one of the most difficult of the enzymes to purify to any extent. The protective colloids, etc., during the purification are separated away from the enzyme aggregate, and the purer ferment becomes less active. The reason for this cannot be very well explained at the present, but it is the experience of all investigators with diastase that this is a fact. However, results were obtained which seemed to indicate that the diseased leaves contain relatively less "diastase" than do the normal healthy leaves.

Chlorophyllase. — This enzyme has been found to be always present with chlorophyll in amounts directly proportional to the amount of chlorophyll present, and according to Willstätter and Stoll[1] does not bring about an hydrolysis but an "alcoholysis,"

$$\mathrm{RCOOC_{20}H_{39} - C_2H_5OH\ .\ RCOOC_2H_5 - C_{20}H_{39}OH}$$

in the presence of ethyl alcohol. It forms the alcohol phytol, $C_{20}H_{39}OH$, from the radical in the presence of ethyl alcohol and not water only.

Very little is known about its action in the plant cell, and although the writer was able to demonstrate its presence in both healthy and diseased leaves, no quantitative data were secured as to its relative activity in healthy and diseased tissue. Until better methods are worked out for its purification and rapid determination it would be futile to hazard an opinion in regard to its specific action in the cells of healthy and diseased leaves.

Oxidases and Peroxidases. — Woods (*loc. cit.*) was one of the first to observe that in mosaic-diseased leaves the oxidase activity was greatly increased. Since then it has been found that in the curly dwarf disease of the potato and sugar beet the oxidase activity is greatly increased in the diseased leaves as compared with that of the normal. These two diseases have been for the most part regarded as physiological, and it is a significant fact that this excessive activity of oxidizing enzymes has been more frequently noted in diseases of this character than in those which are caused by bacteria or fungi. The reaction of the host is apparently different in the latter case.

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[1] Willstätter and Stoll: Unt. über Chlorophyll XI und XIII. Über Chlorophyllasa. Liebig's Ann. der Chemie., 378, 18 (1910); 380, 148 (1911).

Bunzel[1] has noted that the oxidase activity varies with the age of the plant in the curly dwarf disease of potato, reaching its greatest activity when the plant growth ceases.

The writer has also found this to be true for tobacco to a certain extent, and always met with greater activities of the oxidases as the leaves were approaching maturity. This was marked in the case of normal plants, but not so much in the case of diseased leaves.

In the writer's examinations of healthy and diseased tissue not only qualitative colorimetric methods were employed, but also a simplified Bunzel's oxidase apparatus was made use of. This has been found to be the most satisfactory method for the quantitative estimation of oxidase activity.[2]

A few of the quantitative results obtained are given in Table XI.

TABLE XI. — *Oxidase Activity in Normal and Mosaic Sap.*

[Manometer readings in centimeters of mercury. Bunzel apparatus mod.]

EXPERIMENT.	Time in Minutes.	Normal.	Diseased.
A,	0	0	0
	30	—0.60	—0.80
	60	—1.09	—1.23
	75	—1.12	—1.29
	120	—1.22	—1.43
B,	0	0	0
	30	—0.32	—0.50
	60	—0.80	—0.70
	75	—1.02	—0.96
	120	—0.92	—1.21
C,	0	0	0
	30	—0.51	—0.46
	75	—0.63	—0.88
	100	—0.70	—0.91

It will be noticed that the mosaic sap is higher in total and average in every instance.

For the qualitative determinations the usual guaiac test was employed. The guaiac test for oxidases and peroxidases is too well known to require an extended explanation. The results obtained by this method in every case showed the diseased leaves to contain much more oxidases than the healthy ones of the same age; this was also true for peroxidases, but here, of course, the reaction with guaiac was somewhat masked owing to the presence of the oxidases and their reaction.

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[1] Bunzel, H. H.: Oxidases in Healthy and Curly Dwarf Potatoes. Jour. Agr. Research, Vol. II., 5, 373-404 (1914).

[2] Bunzel, H. H.: The Measurement of the Oxidase Content of Plant Juices. U. S. D. A., Bur. Plant Ind., Bul. No. 238 (1912).

In examinations of the roots of healthy and diseased plants the same condition was observable; there was always an excessive activity of the oxidizing enzyme to be noted.

In going over the results of the experiments with the enzymes in question, the main point brought to the attention is that there is in all diseased plants an excessive activity of the oxidizing enzymes, and a corresponding decrease in the activity of the diastatic enzymes and catalase. This at least indicates a very much disturbed equilibrium and a consequent derangement of normal function on the part of the cells. Naturally the ones most affected by this disturbance are the dividing or meristematic cells, as these are the cells upon which the plant is dependent for its subsequent growth, and any deviation from the normal is more likely to be indicated in the development of these cells than in those of the other parts of the plant. Any change in function induced here will leave its imprint to a greater or less extent on the cell during its subsequent existence, hence the peculiar manifestations of the disease in the leaves.

It is true that plants attacked by parasites sometimes show an excessive activity on the part of certain enzymes, but, as a rule, the disturbance is more local in its nature. It is also a fact that malnutrition, such as partial starvation, drought, etc., will bring about an excessive production or activity of the oxidizing enzymes in particular, as has been pointed out by Bunzel, of general distribution throughout the plant; but this, except in cases of maturing plants, changes upon restoration of normal conditions, and tends to become normal.

Reaction of Mosaic Sap with Various Substances.

We have seen that the enzymatic activities of the plant are very much disturbed in disease; also that it has been impossible to demonstrate the presence of any forms of bacteria or fungi either in the tissues themselves or in the expressed juice.

It is a fact, as shown by practically all investigations, that the disease is very infectious. This fact alone in the minds of many is sufficient to place the causative agent among the parasitic organisms. The field, however, is limited to that class of organisms designated as "ultramicroscopic" organisms, about which very little is known, and in the case of plant diseases not even a semblance of the demonstration of the activities of such organisms has been made.

Owing to the fact that the enzyme activities are much changed, as has been demonstrated in the preceding pages, and also to the fact that not only the activities of the oxidizing enzymes are changed, but also the activities of others; it was believed by the writer, with Woods and others, that the disease might be physiological in nature, particularly in so far as the causal agent, not being a living organism in the ordinary conception of the word, was concerned.

So little is known about the action of the so-called ultramicroscopic organisms that it is an open question in the writer's mind whether this division should be the dumping ground for all infectious diseases about the etiology of which little or nothing is known.

It is conceivable that other causes, not organic in nature, may be able to produce the manifestations of parasitism. Under this type of infection would be included infectious diseases caused by enzymes or the resultant product of the activities of a group of enzymes.

Certain reactions of the juice from diseased plants tend to confirm this view, and in the following pages are given the results obtained by the writer and other investigators relating to the reactions of these juices with various reagents.

Drying. — It has been shown by various investigators that the dried leaves of the mosaic-diseased plants retain their infectious qualities for a long time. Beijerinck and Allard found that diseased leaves were capable of causing infection after being dried for periods of two years and eighteen months, respectively. The writer has used material three years old, and obtained infection in a great majority of cases. The results obtained are given below.

TABLE XII. — *Air-dried Mosaic Leaves, finely ground and macerated with Cold, Distilled Water.*

[Leaves (herbarium specimens) three years old.]

Number of Plants inoculated.	POINT OF INOCULATION.	Number of Plants infected.	Per Cent. Infection.
10	Below terminal leaflets, ...	10	100
12	Main stem near base, ...	11	91
7	Midribs of a basal leaf, ...	6	86
13	Midribs of a basal leaf, ...	12	90

Filtration. — The use of various filters such as the Chamberland, Berkefeld and Kitasato types, as a means for the separation of bacteria and other organisms in a fluid, has been widely adopted in recent years, and more recently filters possessing different sized pores have been used for differential diagnostic purposes in work on the so-called "ultramicroscopic" organisms, enzymes and toxins. While these methods are without doubt of importance, it should always be borne in mind that to obtain true filtration effects comparatively large volumes of the fluid should be used, otherwise there is a strong possibility, particularly in the case of enzymes, that instead of a filtration occurring at once, a large amount of certain constituents may be adsorbed (dependent on the nature of the filter), and that true filtration may not take place until comparatively large amounts have been drawn through the filter. The writer has noted this particularly in work with enzymes, many of which are strongly adsorbed by various substances. Aside from the "ultramicroscopic" organisms, however, the bacteria cannot pass through many of these filters.

With reference to the causal agent in mosaic sap it has been found that it passes through both the Chamberland and Berkefeld filters, and even the finer grade of Berkefeld filter allows the passage of the causal agent. Beijerinck (*loc. cit.*) showed that the juice was still infectious after being passed through the Chamberland filter, and Allard (*loc. cit.*) and Clinton (*loc. cit.*) have both shown that the juice was infectious after passage through the Berkefeld (normal) filter. The results obtained by the writer agree with these observations, and also the juice was found to be infectious after passing it through the fine Berkefeld candle. The Kitasato filter was also used, and here positive infection was also obtained, although the percentage was small. The writer attempted to repeat these experiments with the Kitasato filter during the past year, but was unable to obtain the filter. In all cases relatively large amounts of the sap were used after filtration through paper.

The average percentage of infection obtained with each filter in the writer's experiments was as follows: —

	Per Cent.
Chamberland (average of 3 examinations, 1911),	91.0
Berkefeld (normal; average of 5 examinations, 1911),	63.0
Berkefeld (fine; one test only, 1914),	47.0
Kitasato (average of 2 examinations, not dated),	40.5

The work with the fine grade of Berkefeld and Kitasato filters should be repeated, but there are sufficient indications to warrant the insertion of these results at this time.

Resistance to Antiseptics. — The writer has at various times treated filtered and unfiltered juice with many of the antiseptics such as are commonly used to prevent bacterial action.

The following table contains the data and results obtained in one typical series of experiments of this character: —

TABLE XIII.

ANTISEPTIC.	Amount of Sap used (Cubic Centimeters).	Period of Treatment.	Infection.
Toluol (2 c. c.),	10	2 months.	++
Toluol (2 c. c.),	10	4 months.	++
Chloroform (saturated at beginning),	10	2 months.	++
Chloroform (in excess),	10	2 months.	—
Chloroform (saturated at beginning),	10	4 months.	+
Chloroform (in excess),	10	3 days.	—+
Thymol (2 per cent.),	10	2 months.	+
Thymol (2 per cent.),	10	4 months.	+
Ether (saturated),	10	2 months.	+
Ether (saturated),	10	4 months.	+
Formaldehyde (1–4 H_2O, 1 c. c. added),	10	2 months.	—
Formaldehyde (1–4 H_2O, 1 c. c. added),	10	10 days.	—
Carbolic acid (5 per cent., 10 c. c. added),	10	2 days.	—
Chloralhydrate (½ mol.),	10	2 days.	—
Chloralhydrate (½ mol.),	10	20 hours.	—

++ = very infectious.
+ = infectious (over 40 per cent.).
—+ = one or two cases of infection, possibly accidental.
— = no infection.

From the preceding table it may be seen that the sap containing the causal agent of the disease varies greatly in its reaction to so-called antiseptics and other compounds. The writer[1] has already pointed out in a previous publication that the influence of certain capillary active substances on enzymes is very variable, aside from the specific toxic qualities of certain of these substances. In comparing the reaction of the sap containing the causal agent to certain of these compounds we find that there is a similarity of reaction to that shown by the enzymes. In the paper above cited it was shown that those compounds which changed the surface tension had, as a rule, dependent on their physical properties (hydrocolloidal or lipocolloidal), a certain definite effect on enzyme activities.

Taking up the discussion of the results in detail we find in toluol a compound which is not soluble in water to any great extent, and hence, behaving like a lipocolloid, having no effect on the action of the causal agent contained in the sap. Toluol, as a rule, has a more or less definite inhibitory action on living organisms.

Chloroform, when present in the sap not to exceed saturation, behaves also like a lipocolloid, as it is only very slightly soluble in the water, and we find in this case that the activity of the agent is not destroyed. Chloroform in excess, however, does destroy apparently the causal agent of the disease. It is noteworthy that this action of chloroform exactly parallels that found to be the case with enzymes.

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[1] Chapman, George H.: The influence of Certain Capillary-Active Substances on Enzyme Activity. Internat. Zeitschrift für Physik.-chem. Biologie., I Band, 5 u. 6 Heft (1914).

Thymol, when used in 2 per cent. concentration is very often used as a preventive to bacterial action, and also prevents the growth of fungi. We find, however, that when it is present in concentration not exceeding 2 per cent. in the sap the causal agent still possesses its infectious qualities for some time.

Ether is a substance which, like chloroform, has lipoid-like properties, but which has a definite action on the surface tension, lowering it considerably. Sap containing ether to the saturation point, which lowers the surface tension from 1 to about .619, was still infectious four months after treatment, although the percentage of infection was much decreased.

A solution of the sap containing approximately .8 per cent. of actual formaldehyde was very injurious, and at the end of two months no infection was obtained. At the end of ten days in one experiment, however, plants were inoculated and two cases of mosaic disease developed from a series of eight plants, but it is believed that this may possibly have been an accidental infection, as in no other instance was infection obtained. In formaldehyde, however, we have a compound which has a specific narcotic action on certain enzymes aside from its surface activities.

Where carbolic acid was added to a solution of the sap the active principle was apparently destroyed.

In chloralhydrate we have a substance very soluble in water, but not possessing any relatively great surface activity. It has, however, a specific toxic action on the causal agent of the disease, and even after twenty hours no infection was obtained. These results with chloralhydrate are in complete accord with those obtained in the enzyme work previously mentioned.

Most of the substances used in the above experiments possess a very definite toxic action to all organisms, particularly bacteria and fungi. As to their effect on the so-called ultramicroscopic organisms the writer is unable to state, not having had the opportunity of working with so-called cultures of these organisms. The parallelisms between the surface-tension effects of these substances on enzymes and on the sap containing the active principle of the mosaic disease are very striking.

Having shown that the causal agent is not bacterial or fungous in character, we must eliminate for the present the supposition of the presence of a toxin or virus in the pathologist's conception of these terms, as it is usual to conceive of these substances as being either the product of an organism or the activity manifested by the organism itself. As to the production of toxins and viruses by the so-called ultramicroscopic organisms little is known. Noguchi was the first to apparently demonstrate that such organisms do exist, and was able to cultivate an organism obtained from the brain of patients suffering from infantile paralysis.

However, these organisms were always mixed with certain bodies probably of a protein nature, and Noguchi, himself, so far has been unable to state absolutely which may be the active agent, although he naturally infers from his inoculation experiments that the organisms found must be the causative agent owing to the extreme infectious character of the disease. He, however, states that it is not absolutely clear to him whether the organism alone or a combination of this organism with the bodies found in culture associated with it are capable of producing infection. He does state, however, that in the case of *animal* pathology no such symbiotic relationship has so far been observed. From the character of his statement, however, it is clearly indicated that he does not preclude the possibility of such a condition arising.

Probable Character of the Causal Agent.

The question as to the exact character of the causal agent of mosaic disease has been an extremely interesting one to investigators, and studies on this phase of the problem have narrowed the field by the elimination from consideration of fungi and bacteria, as has previously been shown not only in this work, but also by many other investigators. This also precludes the presence of a virus or a toxin resultant from the activities of such organisms.

This leaves, then, for consideration as the causal agent an "ultramicroscopic" or "invisible" organism and the enzymic activities in their fullest conception. The reactions of the so-called "ultramicroscopic" organisms are little known at present, and about the only grounds for admitting of such a class of organisms is the *infection* factor, and possibly *reproduction* to a certain extent. We do know, however, many reactions of the class of substances called enzymes and toxins, but fundamentally the differentiation of the three above mentioned is difficult, and is perhaps in many cases impossible. Working with filtered sap from mosaic-diseased plants, we get the following results in comparison with reactions of some of the so-called "ultramicroscopic" organisms and toxins.

Temperature. — The sap containing the causal agent of mosaic disease becomes non-infectious; in other words, becomes inactive when heated to about 80° C. for a short time. It is reported that ultramicroscopic organisms and toxins are killed or rendered inactive, respectively, by exposure to heat for any length of time at temperatures somewhat below 100° C. Enzymes are also rendered inactive at temperatures somewhat below 100° C. All three react practically alike as regards temperature. The causal agent in mosaic sap, as may be seen, is also rendered inactive at temperatures below 100° C.

Size. — As to size, nothing can be definitely stated, but it is a fact that the ultramicroscopic organisms, enzymes and toxins must have a diameter of less than .1 μ, otherwise they would become visible under the higher powers of the microscope. In no case has it been possible to demonstrate the presence of organisms under even the highest powers available.

Reaction to Antiseptics. — It is stated that the ultramicroscopic organisms are not, to any extent, affected by the ordinary antiseptics, and the same is true for toxins in general. On the other hand, enzymes and their activities are very strongly affected by the substances usually made use of as antiseptics, and this is found to be true, with one or two possible exceptions, in the case of mosaic sap. It has been shown that formalin, carbolic acid, chloralhydrate, and even chloroform in excess, will inhibit the activities of the causal agent in mosaic sap, while, on the other hand, such substances as ether, toluol, thymol and chloroform in dilution have little or no effect. While all three classes are to a certain extent affected by antiseptics in general, the enzyme group is most strongly affected, and in the case of the mosaic we find this reaction; also, as has been pointed out, the effect of substances possessing marked surface-active properties is, in the case of mosaic sap, quite analogous to that of these substances on enzymes. It had been hoped to carry on more detailed work on this point, but as yet no opportunity has offered to take up this phase of the matter. Allard[1] has studied the effects of alcohol, ether and other substances on mosaic sap, and an interpretation of his results, with particular reference to the surface-active properties of the substances under consideration by him, parallel the author's findings in the case of enzymes to a marked degree. It is believed that more work of this character might throw considerable light on this matter.

Activity. — So far as can be judged from laboratory results the activity of the causal agent in mosaic sap is continuous, and as this holds true not only for organisms but, within limits, for enzymes and toxins as well this property cannot be made use of for differential purposes.

"Koch's Laws" or "Postulates," so called, are followed by all three of the classes under consideration, and the same is true in the case of mosaic disease; the causal agent obeys these laws, and might well be placed in any one of the classes so far as this property is concerned.

The Kitasato filter has been used by some as a means of separation of "ultramicroscopic" organisms from enzymes and toxins, and although the arbitrary use of any one filter as a standard, unless the size of pores, adsorption properties, thickness of walls, etc., are carefully taken into consideration, may be open to question, this procedure has been followed in some instances in animal pathology, and it has been found that the Kitasato filter held back the organisms and that no infection could be obtained from the filtrate. In the case of the mosaic disease, however, we find that apparently, as has been previously indicated in this paper, where large volumes are used, the causal agent passes through the Kitasato filter, and we do get infection from the filtrate.

The disease is infectious, but whether the infection may be indefinitely transferred through several plants with undiminished virulence is open to question. On some varieties of tobacco this does not apparently take place, but so far as the writer's observations go the virulence of the causal agent is not lessened appreciably. This property is one of the strongest points advanced by those favoring the theory of the presence of a definitely organized parasite as the causal agent of the disease. It is, however, entirely possible that enzymes or similar substances introduced into a plant even in extremely small quantities, are capable of regeneration of a certain kind, and indeed it is held by some that enzymes do *grow* and even reproduce themselves under certain conditions. The difficulties encountered in the study of this phase of enzyme work are very great, however, and it is questionable if such statements can be as yet definitely accepted.

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[1] Allard, H. A.: Some properties of the virus of the mosaic disease of tobacco. Journal Agr. Research, Vol. VI., No. 17 (July, 1916).

Organisms, even of the ultramicroscopic class, in their reactions would not follow the law of proportionality, but in the case of mosaic sap and its reactions we find, by measuring the relative activities and reactions of the enzymes present that apparently a proportionality of reaction for any one lot of sap does hold. The writer has very often found in the measurement of the activities of the catalase and oxidase particularly that not only a fairly definite relation exists between the various enzymes, but that reaction of any one is dependent on the amount of sap used. Of course, here we are dealing with a mixture, and it may be open to question if the measurement of the enzyme activities is a true measure of the activities of the causal agent.

The whole subject of the differential diagnosis of enzymes, toxins and ultramicroscopic organisms is an extremely difficult one, and no sharply dividing lines can properly be drawn between them. It would appear to the writer that in some cases, at least, it is entirely dependent on the viewpoint and interpretation of the investigator as to the class to which certain diseases should properly be ascribed.

The factors of reproduction and infection, as ordinarily understood, have proved a stumbling block to the acceptance of the idea that there may be other forms of matter aside from organisms capable of reproducing a disease, but there is in reality very little real ground for taking this attitude. In the case of the mosaic disease there are certainly many reactions which will not allow of placing the causal agent in the class of ultramicroscopic organisms. The general distribution of the causal agent in a diseased plant, its exceedingly localized action on the meristematic tissues, this action being apparently confined to the nascent chlorophyll, the non-uniformity of response to apparently favorable conditions during any one season even on one field, and also its individualism as shown by plants growing together (one often diseased and the other not) are to the writer indicative of something of a different character.

It is also possible that in the search after the infinitesimal the fact that a highly organized plant as a whole may react in the same manner as some of the simpler organisms has been overlooked. It is as a rule not the presence of an organism alone which is responsible for the manifestations of disease, but the products of the metabolism of the organism.

If the metabolic processes are changed ever so slightly, due to any stimulus, far-reaching effects may be induced throughout the organism, and this we find to be the case in the mosaic disease, and the writer believes that it is justifiable to look upon the matter in this light, as it is no more hypothetical than the concept of an "ultramicroscopic" parasite, which, if demonstrated (and no amount of concentration or methods of culture have indicated in any way the presence of aggregates or colonies), certainly would become visible if multiplication occurred.

Theoretically is it possible to conceive of an organism, functioning as such, to be made up of so few molecules of protein, fat and carbohydrate that it would be impossible to demonstrate its presence? If so, our ideas of relative size of molecules of protein, etc., must be changed.

Prevention and Control.

The question of the prevention and control of mosaic disease is of prime importance to the grower, entirely aside from more technical considerations as to the exact cause or causes of the disease, and it is believed that with reasonable care it is possible for the grower to lessen materially the amount of mosaic in the field.

Many recommendations have been made regarding treatment of diseased plants after they have once contracted the disease, but so far the writer has never observed a plant which, once attacked by the disease, recovered at any subsequent period of its growth. On the other hand, it has never been observed that the disease killed a plant, at least in this region.

It is doubtful, owing to the character of the disease, if it can ever be entirely eliminated on some soils and under certain unfavorable conditions occurring during some seasons. As has been indicated previously there is apparently little or no relation to be found between excess or lack of food materials and the prevalence of the mosaic. It has been in some instances stated that favorable results have been obtained from the use of lime in different forms, but this treatment cannot be recommended for various reasons. Experimentally it has been shown that heavy liming has little or no effect on the disease once a plant has contracted the disease, and even when applied to soils from old beds no consistently favorable results have been obtained (see page 91). Used in the larger quantities it might be inferred from the results that the lime apparently did exert a beneficial action, but to apply lime generally in such amounts would be folly, as it would in many cases bring the soil to a comparatively neutral or alkaline condition, which reaction would favor the development of root rot, caused by the fungus, *Thielavia*, and this, once thoroughly established, in a field or seed bed, is much more injurious to tobacco than is the mosaic disease.

As has been pointed out, the writer, from his observations, is strongly of the opinion that much of the field infection may be traced to the seed bed, and as a rule those beds which have long been used or carelessly handled are found to be producers of mosaicked seedlings in far larger numbers than are found on new beds or on beds which have been carefully sterilized either by steam or formalin.

It has been found that the soils of old beds do tend to produce more mosaicked plants than do those of new beds, although it may be possible that under field conditions the differences in amount during different seasons may vary. Soils brought into the greenhouse gave the following results: —

TABLE XIV. — *Experiments with Soils from Old and New Beds.*

[Seedlings transplanted in sterilized soil.]

SOIL.	Number of Seedlings transplanted.	Number Diseased Four Weeks after Transplanting.	Diseased (Per Cent.).
Soil A (old bed),	60	45	75.0
Soil 21 (old bed),	43	17	40.0
Soil I*a*,	50	21	40.0
Soil B (new bed),	30	3	10.0
Soil C (new bed),	49	2	4.0

The soil from the old beds was in very bad condition and had been very carelessly handled, apparently.

A count of mosaicked seedlings left in these old-bed soils six weeks after the transplants was taken, showing, respectively, an infection of A, 43 per cent.; 21, 32 per cent.; I*a*, 17 per cent.; B, 6 per cent.; and C, 7+ per cent.

It is evident that some of the seedlings were infected during transplanting, probably by handling diseased seedlings and then healthy ones, thus transmitting the disease. This method of transmission at the time of transplanting is very common, as has been pointed out repeatedly.

It has been shown that much of our infection may originally come from the seed bed as a result of the soil becoming infected for any reason. The use of tobacco stems and tobacco water has also been found by many investigators to cause infection. The amount of infection resulting from watering beds with water extract of diseased stems is, however, problematical, and it is not believed by the writer that this is an important factor in mosaic transmission, especially if the stems are steeped in hot water. The broken, decaying roots of diseased plants left in the beds also carry the causal agent of the disease as do the stems of diseased plants, and freezing has apparently little or no effect on it, so the use of stems on the seed bed should be carefully attended to in order not to apply any from diseased plants. Where stems and tobacco water are applied year after year without attention to this point the bed usually becomes more seriously infected.

One of the cheapest methods for the control of this disease in the seed bed, where it can be advantageously carried out, is to change the location of the beds to soil on which no tobacco has been grown, and to avoid the use of stems and tobacco water. Occasionally, however, some slight infection will occur even here, but as a rule not to any great extent. If proper attention is paid to watering, ventilation, etc., little trouble of this character is to be expected in new seed beds.

It has been shown in Connecticut and elsewhere that a thorough sterilization of the seed bed by steam at a boiler pressure of from 70 to 90 pounds is also a satisfactory method for the control not only of fungous diseases but weeds also, and the same holds true for the mosaic disease. The writer has seen this tried a number of times with excellent results where the above-mentioned pressures have been used. Some growers, however, seem to be of the opinion that the prime value of steaming is to kill weed seeds, and so use low pressures. While low pressures will kill weed seeds, it is questionable if they will sterilize the soil sufficiently to kill the spores of fungi or render inactive the causal agent of the mosaic, although under laboratory conditions it is rendered inactive at temperatures of about 80°C, equivalent to 176°F. In some of our experiments conducted some years ago it was strongly indicated that improper partial sterilization would not entirely rid the soil of the causal agent of mosaic.

It might be stated here that, in many cases where the growers have reported failure in the control of diseases after steam sterilization, inquiry has usually brought out the fact that too low pressure was used, and as a result thorough sterilization was not obtained. Another source of failure of beds after sterilization with steam, under high pressure, has been that the grower has not paid sufficient attention to watering. This matter should be closely attended to, as a sterilized bed, particularly on light soils, dries out very quickly, and needs much more attention than is usually given a bed under ordinary conditions. If the watering is neglected there is very often a severe checking of the germination of the seed, and in some cases a partial loss of the bed.

Formalin sterilization may also be used, and is quite as satisfactory, especially when used on light soils. On heavy soils it is not quite so convenient to apply, however. Where formalin is used the beds cannot be sown until all the formalin is out of the soil, which usually takes from ten days to two weeks. This very often is too long a delay, particularly where spring sterilization is practiced.

It has been pointed out that the workmen may be a rather important factor in transmitting the disease (page 88), and in cases where at transplanting time diseased seedlings are handled it has been recommended by Clinton[1] that the hands be thoroughly washed in soap and water before again handling healthy seedlings. If these precautions are taken, according to Clinton, a considerable amount of mosaic infection will be avoided at the time of planting.

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[1] G. P. Clinton: Chlorosis of Plants with special reference to Calico of Tobacco. Conn. Agr. Exp. Sta. Rept., 1914, p. 417.

It has been repeatedly shown that care should be exercised during early cultivation not to cut the roots or touch broken or abraded leaves of plants and then subsequently touch other plants, for the disease is very easily transmitted in this way, as the fine hairs or epidermis may be broken and infection occur. The amount of infection due to cultivation is, however, in the writer's opinion, slight, but as much care as is commensurate with efficiency should be exercised by the workmen during cultivation.

The advisability of the removal of diseased plants is open to question, and on the whole it cannot be economically recommended unless the plants can be replaced early in the season. As has been previously pointed out, the disease may be carried from plant to plant when topping, etc., and the subsequent sucker growth will become mosaic. At this time, however, the commercial leaves are of such size that their value will not be materially impaired, but if possible, to prevent a certain amount of infection, only healthy or diseased plants should be topped at any one time. Of course, all suckers developing later, diseased or otherwise, should subsequently be removed from all plants, not only for the sake of the commercial leaves, but to prevent a ragged looking field, giving the appearance of a large amount of mosaic.

It has been very difficult to associate any particular type of soil with general occurrence of mosaic disease, but on the whole, from data gathered at different times, the heavier types of soil in the valley appear to be more generally favorable for the production of mosaic-diseased plants. This cannot be definitely stated, however, as the data are complicated by the fact that in some cases, on both heavy and light soils, the condition of the soil as regards organic matter present enters into the question. The writer has observed that on many heavy soils where comparatively large amounts of organic matter are present during certain seasons, in comparison with similar soils deficient in organic matter, the mosaic is much less. To a certain extent this holds true also for the lighter soils. The exact relation existing between the mosaic disease and these factors is at present not enough studied to warrant definite conclusions, but Sturgis (*loc. cit.*) was of the opinion that clayey soils were favorable to its production. It is a significant fact that many of our tobacco soils are somewhat deficient in organic matter, however. Well-cultivated and consequently well-aerated soils do not apparently produce as many mosaicked plants as those which are not well cultivated.

Another factor which should be carefully attended to is that of the moisture conditions in the bed at the time the plants are pulled. It should not be too moist nor too dry, as in either case the roots are apt to be broken and infection from handling result more certainly than when the plants are removed with a minimum of root injury.

SUMMARY.

1. The mosaic disease is not caused by fungi or bacteria. It has never been possible to demonstrate the presence of these organisms in the tissue of any part of the plant.

2. The disease is highly infectious, particularly when inoculated into young plants, all subsequent growth exhibiting marked symptoms.

3. The disease is not contagious.

4. Until more is known about the action of the so-called "ultramicroscopic" organisms, the disease cannot be ascribed to an organism of that class, as the character and reactions of the causal agent do not in many respects coincide with reactions of that class of organisms.

5. Many of the reactions of the causal agent are of such a nature as to indicate that it is either an enzyme, an aggregate of enzymes, or the product of enzyme activities.

6. The enzyme activities of diseased plants are greatly altered, far more than is usually the case in plants which are attacked by pathogenic fungi or bacteria.

7. As a result of the writer's experiments, it is believed that the disease is primarily induced by a disturbance in the enzyme activities and their relation to each other, due to abnormal metabolism, and not by any parasite.

8. The pathogenicity of a disease is not necessarily a proof that it is of parasitic origin, as it is conceivable that similar conditions may exist relative to enzyme activities, although the extent of such action is not known at present.

9. On fields where the mosaic disease is prevalent, the primary infection can usually be traced to the seed bed, and many healthy seedlings are infected by the workmen when setting the plants. It is estimated that about 80 per cent. of the infection occurs in this manner.

10. Owing to the nature of the disease the matter of absolute prevention and control is difficult, but with careful attention to details of sterilization of the seed bed, and handling of the plants at time of transplanting, a large percentage of infection may be avoided.

BULLETIN No. 176.

DEPARTMENT OF CHEMISTRY.

THE CAUSE OF THE INJURIOUS EFFECT OF SULFATE OF AMMONIA WHEN USED AS A FERTILIZER.[1]

BY R. W. RUPRECHT AND F. W. MORSE.

PART I. — CHEMICAL INVESTIGATIONS.

In a previous report[2] there has been described how the continued use of sulfate of ammonia on the experiment plots called "Field A" caused the removal of lime in the drainage waters in the form of calcium sulfate, and when lime was not present in sufficient quantity there were formed noticeable amounts of aluminium sulfate and iron sulfate, but that no accumulation of free acid could be found.

Since comparatively little material had been published on the formation of salts of aluminium and iron in soils, it was considered advisable to continue the investigations, and as the work progressed it was found that soluble manganese salts were also present in some of the soils to which sulfate of ammonia had been applied.

The present bulletin is a report of our investigations into the relations between sulfate of ammonia and salts of aluminium, iron and manganese, and the quantities of these salts which will injure clover seedlings.

Soils from plots 1, 6, 7 and 8 of Field A were used to determine how freely ammonium sulfate solutions would extract manganese from them. The soils have been fully described in Bulletin No. 165, but for convenience the fertilizers used on these four plots will be described here.

Each plot received dissolved boneblack at the rate of 500 pounds per acre, and muriate of potash 250 pounds per acre. Plot 1 received 300 pounds of nitrate of soda per acre; plots 6 and 8 received 225 pounds of sulfate of ammonia per acre; and plot 7 received no nitrogenous fertilizer. In 1909, and again in 1913, hydrated lime was applied to one-half of Field A, crosswise of the plots. The total amount in the two dressings was 9,000 pounds per acre.

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[1] The work reported in this bulletin, together with the material published in Buls. Nos. 161 and 165, was submitted by Mr. Ruprecht to the faculty of the graduate school of the Massachusetts Agricultural College in part fulfillment of the requirements for the degree of doctor of philosophy.

[2] Bul. No. 165, "The Effect of Sulfate of Ammonia on Soil."

The ammonium sulfate solutions were used in the manner described in Bulletin No. 165, viz.: 150 grams of air-dry soil were placed in a large flask with 750 cubic centimeters solution and shaken frequently for two hours. The solution was then filtered through paper, which gave a clear filtrate with a yellowish tint.

Manganese was determined by the colorimetric method described by Schreiner and Failyer,[1] in which the manganese salts are oxidized to permanganate by nitric acid and lead peroxide.

The strengths of the solutions were tenth-normal (N/10) and normal (N). The results obtained by the extracts from unlimed soils are tabulated in Table I., together with the amounts of iron obtained from the same soils in our previous work, and reported on page 81 of Bulletin No. 165.

TABLE I. — *Milligrams Manganese Oxide* (Mn_3O_4) *and Iron Oxide* (Fe_2O_3) *obtained from 100 Grams Air-dry Soil by Ammonium Sulfate Solution.*

PLOT.	MANGANESE OXIDE.		IRON OXIDE.	
	N/10 Solution.	N Solution.	N/10 Solution.	N Solution.
1,	Trace.	.58	.40	.79
6,	.88	1.52	.46	.51
7,	Trace.	1.18	.43	.50
8,	.63	1.45	.89	1.21

The stronger solution removed much more manganese than the weaker, but not in proportion to its strength. The fertilization of plots 6 and 8 with ammonium sulfate evidently produced some manganese compounds that were readily soluble in the solutions, since there was more manganese obtained from those plots than from the other two.

From the limed soils of these four plots there was removed no manganese by N/10 or N solutions, but when stronger solutions of ammonium sulfate were used (2½ N and 5 N), traces of manganese were found in the soil extracts. This would appear to be due to the presence of enough ammonium sulfate in the concentrated solutions to overcome the lime and act upon the manganese in the soil.

Since iron had been found by color tests to be generally present in water extracts from the unlimed soils of Field A, while aluminium could rarely be detected by the precipitation test with ammonium hydroxide, it was decided to try larger quantities of soil and larger volumes of water, which would permit subsequent concentration and perhaps yield measurable quantities of these elements by the usual analytical methods.

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[1] Bul. No. 31, Bureau of Soils, U. S. Dept. Agr., 1906.

Eight kilograms of air-dry soil were put in a percolation jar, the tubulure of which was covered with a piece of linen and plugged loosely with glass wool. Enough water was added to saturate the soil, which was then left in the wet condition for two days. Water was then added in portions of 1 liter at a time, each of which ceased dropping from the bottom of the jar before another was added. Eight liters were thus used, and the percolated water was evaporated in a porcelain dish on the water bath until the volume was reduced to 1 liter, which was next filtered through paper and finally through a porcelain filter under pressure, as there was a turbidity which paper would not remove.

The clear soil extract was next heated and made slightly alkaline with ammonium hydroxide. A copious flocculent precipitate formed, which was collected on a filter, washed and then analyzed. When the filtrate was further heated and a few drops of ammonia added, a second precipitate, similar to the first, formed and was also analyzed. The two precipitates differed but little in composition, and the results obtained were combined in Table II.

TABLE II. — *Constituents of Precipitate obtained in Concentrated Soil Extract, expressed as Milligrams in 100 Grams of Soil.*

	Plot 1.	Plot 6.	Plot 8.
Aluminium oxide (Al_2O_3),	.074	.152	.105
Silica ($Si O_2$),	.381	.538	.835
Manganese oxide (Mn_3O_4),	None.	1.596	.362
Calcium oxide ($Ca O$),	1.955	None.	.225

The precipitate was found to contain but a trace of iron, which is not tabulated as such, but is really included in the aluminium oxide. The calcium which separated in the ammonium hydroxide precipitate was apparently in the form of carbonate, as the precipitate from the extract of plot 1 effervesced vigorously when dissolved in hydrochloric acid, as the first step in analysis.

There is a striking difference between the precipitate obtained in the soil extract from plot 1 and those from plots 6 and 8. The protective effect of nitrate of soda on the calcium in the soil is shown in contrast to the depleting influence of ammonium sulfate, with the consequent formation of salts of manganese and aluminium. No effort was made to estimate possible calcium or manganese not precipitated by the successive additions of ammonium hydroxide.

A second series of percolation experiments was tried in which but 1 kilogram of soil was used, and proportionately smaller amounts of water were percolated through it, until the total percolate amounted to 1 liter. The percolate was filtered through porcelain and subsequently yielded no precipitate with ammonium hydroxide.

Iron and manganese were both found and determined by the colorimetric methods. Both limed and unlimed soils from plots 1, 6, 7 and 8 were used in this series. All the extracts yielded colorimetric tests for iron, but only those from the unlimed soils showed any manganese. The results on the unlimed soils are given in Table III.

TABLE III. — *Milligrams Manganese Oxide (Mn_3O_4) and Iron Oxide (Fe_2O_3) removed in Water from 100 Grams of Unlimed Soil.*

	Plot 1.	Plot 6.	Plot 7.	Plot 8.
Manganese oxide,	Trace.	1.49	.49	.47
Iron oxide,	.04	.07	.09	.06

The amounts of manganese from the soils of plots 1, 6 and 8 are closely like those obtained in the previous series with 8 kilograms of soil.

The iron obtained is about one-half the amount of aluminium oxide tabulated in the previous series.

There were in the laboratory samples of soil from plots 5 and 6 which were collected four years before, in 1912. Plot 5 had received the same amount of sulfate of ammonia that had been applied to plot 6. Both samples were from the unlimed halves of the plots. One kilogram of each was treated as in the previous experiment. The extracts showed the presence of aluminium and iron, but were most striking in the tests for manganese. Plot 5 yielded 2.36 mg. Mn_3O_4, and plot 6 yielded 3.18 mg. Mn_3O_4, from 100 grams of soil. This shows that the formation of salts of aluminium, iron and manganese by ammonium sulfate was as marked four years ago as in 1916.

All these experiments showed that ammonium sulfate persistently formed soluble salts of aluminium, iron and manganese in the soil of Field A.

It was next decided to secure samples of soils from other fields that had received ammonium sulfate as a fertilizer over a considerable period of time. The desired soils were obtained from the agricultural experiment stations of Ohio and Rhode Island by the kindly co-operation of Director Thorne and Director Hartwell.

The soil of the Ohio experiment field is a rather heavy clay loam. The samples were taken from Section C of the continuous five-year rotation experiment described in Circular No. 144 of the Ohio Agricultural Experiment Station. The plots selected for our purpose were Nos. 8 and 24.

Since 1893 each plot had received acid phosphate and muriate of potash, but plot 8 had not received any nitrogenous fertilizer, while plot 24 had been dressed with sulfate of ammonia at the rate of 220 pounds per acre during each five-year period. One-half of each plot had received ground limestone annually at the rate of 2 tons per acre since 1908, while the other half had received none during that period.

The plots were seeded with clover at the time the soil samples were taken in the fall of 1915.

In a letter regarding the samples, Director Thorne said: —

> For several years there has been practically no clover on the unlimed ammonium sulfate plots in our work. There are occasionally a few scattering plants, but probably not 20 plants on the twentieth-acre plot. . . . When ammonium sulfate is neutralized with lime we get a luxuriant growth. . . . There are usually at the beginning of the season as many clover plants on the unlimed as on the limed land, but they do not get much beyond the nutriment furnished by the seed, and by harvest have disappeared.

The soil of the Rhode Island experiment field is a sandy loam. The samples for our use were taken from the permanent plots numbered 23, 25 and 29, which have been repeatedly described in the annual reports of the Rhode Island Agricultural Experiment Station.

All three plots have received acid phosphate and muriate of potash since 1893. Plots 23 and 25 have been supplied with nitrogen in sulfate of ammonia, while plot 29 has had nitrate of soda. Plots 25 and 29 have at irregular intervals received applications of lime, and in 1915 all three plots received a dressing of it, but in different amounts. Plot 23 received the equivalent of 500 pounds calcium oxide per acre, plot 25 received 1,500 pounds, and plot 29 received 1,000 pounds. This application of 500 pounds per acre on plot 23 was the first in its history, and was made, as Director Hartwell stated, ". . . because it was becoming so very unsuitable for crop growth."

The soils were prepared for investigation by drying them at a moderate temperature, and then sifting them through a coarse screen with seven meshes to the linear inch, which is the same treatment that was used with the soils from Field A.

The samples from Rhode Island were used in percolation experiments with quantities of 1 kilogram of soil and 1 liter of percolated water.

The clay of the Ohio soils rendered this method impracticable because the water percolated very slowly. The Ohio samples were accordingly put in stoppered bottles, with twice as much water as there was soil by weight, and shaken continuously for two hours in a machine. The solutions were first filtered through paper and finally through porcelain filters.

Aluminium, iron and manganese were tested for, and when present in measurable quantities their amounts were determined.

Aluminium could not be obtained in appreciable quantity from any but the soil from plot 23 of the Rhode Island field. No manganese was found in the extracts from any Rhode Island sample, but was obtained from all the Ohio samples. Iron was extracted from all but the more heavily limed soils.

TABLE IV. — *Milligrams of Aluminium Oxide (Al_2O_3), Iron Oxide (Fe_2O_3), and Manganese Oxide (Mn_3O_4) removed in Water from 100 Grams of Soil.*

[Soils representing Ohio and Rhode Island experiments with ammonium sulfate.]

	Aluminium Oxide.	Iron Oxide.	Manganese Oxide.
Ohio plot 8, limed,	None.	Trace.	Trace.
Ohio plot 8, unlimed,	None.	.05	.16
Ohio plot 24, limed,	None.	None.	.03
Ohio plot 24, unlimed,	None.	.03	.64
Rhode Island plot 23,	3	.27	None.
Rhode Island plot 25,	None.	Trace.	None.
Rhode Island plot 29,	None.	None.	None.

The Ohio soil which had received sulfate of ammonia (plot 24) without lime gave a striking reaction for soluble manganese salts similar to our own soils; but in the soils from Rhode Island the sulfate of ammonia seemed to exert its influence on aluminium and iron compounds (plot 23).

At a later period samples of soil were received from Prof. F. D. Gardner of Pennsylvania State College, which were taken from different plots on the permanent experiment field at that institution. The soil of the field is a clay loam. The samples were taken from plots 31, 32 and 36.

Plots 31 and 32 had received equal amounts of dissolved boneblack and muriate of potash. Plot 31 had sulfate of ammonia applied at the rate of 240 pounds per acre every two years, while plot 32 received 360 pounds per acre in the same period. Plot 36 received no fertilizer. This treatment had been in vogue since 1885.

One kilogram of air-dry soil was treated with water by the percolation method.

Plot 32 with the heavier application of ammonium sulfate yielded strikingly more iron and a little more manganese than plot 31.

The unfertilized soil, plot 36, yielded the most iron, but a negligible amount of manganese.

Table V. — *Milligrams of Iron Oxide (Fe_2O_3) and Manganese Oxide (Mn_3O_4) removed in Water from 100 Grams of Soil.*

[Soils representing Pennsylvania experiments with sulfate of ammonia.]

	Plot 31.	Plot 32.	Plot 36.
Iron oxide,	.28	.58	.82
Manganese oxide,	.13	.15	.01

The results of the chemical investigation of the effect of sulfate of ammonia as a fertilizer in constant use on soils of four different experiment fields show the accompaniment of soluble salts of either aluminium, iron or manganese, or all three together, in the absence of a base like lime. In the presence of calcium carbonate, water has removed no observable amounts of aluminium or manganese salts, and bare traces of iron salts, indicating that lime either reacts with the ammonium salt promptly, or subsequently breaks up the salts of aluminium and manganese, and also iron salts, almost completely.

Part II. — Water Cultures.

Our investigation of the effects of sulfate of ammonia on the soils of Field A included in its progress several series of water cultures in which seedlings of rye, barley and clover were used to study the possibilities of poisonous effects from the presence of soluble substances in the soils. In the earliest series there were used water extracts made from soils of plots 1, 6, 7 and 8 for the purpose of learning whether the injurious effect of ammonium sulfate applied to the soil would appear in the solution obtained from the soil.

The soil extracts were prepared in sufficient quantity by mixing soil and water in the proportion of 1 part by weight of soil to 2 parts of water, shaking frequently during a period of two hours, and then allowing the liquid to clear by settling. The water extract was then carefully decanted from the soil. A part of this extract was filtered through porcelain, under pressure, to see whether the poisonous substances, if present in the extract, were colloidal in their nature.

Discs of paraffine, reinforced by wire gauze and punctured with numerous holes, were arranged by means of suitable corks to float on a basin of water flush with the surface. On these discs the seeds were moistened sufficiently to germinate, and their radicles then penetrated through the holes into the water below. The plan was essentially that described in Bulletin No. 70, Bureau of Soils.

As soon as the seedlings were large enough for the purpose, selected ones were transferred to wide-mouthed bottles, which contained the soil extracts. Each bottle contained 250 cubic centimeters, and 4 seedlings were supported in each one through notches cut in the cork stopper. The different series were grouped as follows: —

Plot 1.

Rye Seedlings.

Unlimed soil, unfiltered extract.
Unlimed soil, filtered extract.
Limed soil, unfiltered extract.
Limed soil, filtered extract.

Clover Seedlings.

Unlimed soil, unfiltered extract.
Unlimed soil, filtered extract.
Limed soil, unfiltered extract.
Limed soil, filtered extract.

The same arrangement was maintained for the soils of plots 6, 7 and 8, and each extract was tested in three different bottles with a total of 12 seedlings. The cultures were maintained for four weeks, at the end of which the seedlings had begun to wilt.

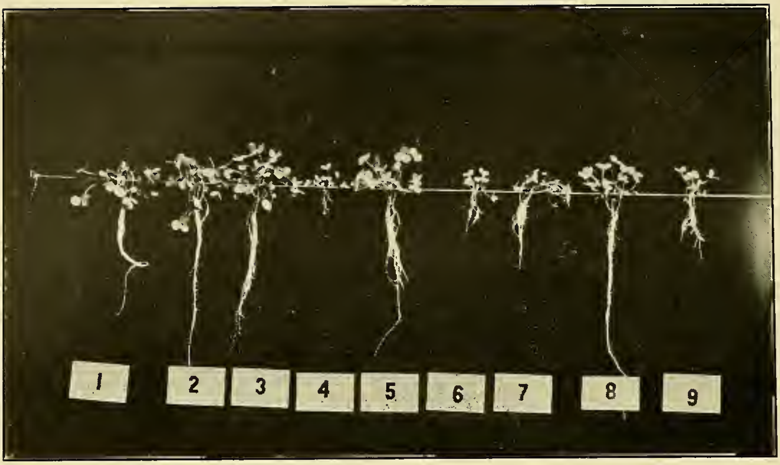
Differences in the seedlings were noted by the end of the first week. Those growing in the extracts from the limed soils were noticeably better as a whole than those in extracts from unlimed soils. Rye seedlings in the unlimed extracts had reddish stems and grew less rapidly. Roots of the clover seedlings in unlimed extracts began to appear stunted; especially so in the unlimed extracts from plots 6 and 8. When the experiment was discontinued the best seedlings had developed in the extracts from the limed soils of plots 6 and 8, while the poorest plants were in the extracts from the unlimed soils of the same two plots. The roots of the clover in these two extracts were short and thick and lacked branches. Filtered extracts produced the same results as unfiltered ones.

A lot of barley seedlings was next used in the unfiltered soil extracts. At the end of the first week the roots in the unlimed extract from plot 6 began to look stunted. By the end of two weeks the seedlings in all the unlimed extracts showed a tendency to wilt and the tips of the leaves turned white. At the end of the fourth week, when the experiment was stopped, the seedlings in the extracts from the limed soils were uniformly superior to those in the extracts from the unlimed. The poorest seedlings were in the extract from the unlimed soil of plot 6.

The strikingly inferior growth of the different kinds of seedlings in the extracts from the unlimed soils of plots 6 and 8, which had been dressed with ammonium sulfate, suggested that the poisonous effect might be due to sulfates of aluminium, iron or manganese, which were known to occur in extracts from those soils.

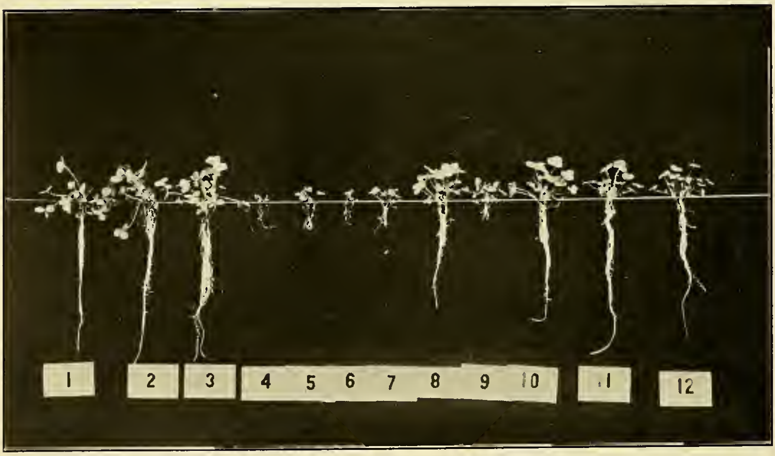
More culture experiments were accordingly tried from time to time, in which standard nutrient solutions were used instead of soil extracts. Vari-

PLATE I.



No. 1, Nutrient sol.; No. 2, Nutrient sol.+$CaCO_3$; No. 3, Nutrient sol.+$CaSO_4$; No. 4, Nutrient sol.+2 c.c. Al sol.; No. 5, same as No. 4+$CaCO_3$; No. 6, same as No. 4+$CaSO_4$; No. 7, Nutrient sol.+1 c.c. Al sol.; No. 8, same as No. 7+$CaCO_3$; No. 9, same as No. 7+$CaSO_4$.

PLATE II.



No. 1, Nutrient sol.; No. 2, Nutrient sol.+$CaCO_3$; No. 3, Nutrient sol.+$CaSO_4$; No. 4, Nutrient sol.+5 c.c. Fe sol.; No. 5, same as No. 4+$CaCO_3$; No. 6, same as No. 4+$CaSO_4$; No. 7, Nutrient sol.+2 c.c. Fe sol.; No. 8, same as No. 7+$CaCo_3$; No. 9, same as No. 7+$CaSO_4$; No. 10, Nutrient sol.+1 c.c. Fe sol.; No. 11, same as No. 10+$CaCO_3$; No. 12, same as No. 10+$CaSO_4$.

ous proportions of ferrous sulfate were added in one series, aluminium sulfate was used in a second series and manganous sulfate in a third.

The standard nutrient solution was prepared in two parts: (*a*) 20.5 grams manganesium sulfate in 350 cubic centimeters of water; and (*b*) 40 grams calcium nitrate, 10 grams potassium nitrate, 20.56 grams disodium phosphate in 350 cubic centimeters of water. From each of the solutions (*a*) and (*b*) were taken 100 cubic centimeters and added to 9,800 cubic centimeters of water, together with a few drops of ferric chloride solution. This diluted nutrient solution was used in the culture bottles.

Seedlings of red clover were used in all these experiments with nutrient solutions, because clover had shown the greatest susceptibility to the soil influences on Field A.

The experiments with sulfates of aluminium and iron have been fully described in Bulletin No. 161 of this station, and only a summary of the results is given here.

Effects of the aluminium and iron salts began to show by the end of the first week, in stunted, thickened roots, followed in a few days by a smaller growth of leaves, when compared with seedlings in the check nutrient solutions. Cultures with 43 parts of aluminium in a million, or with only 44 parts of iron, produced these effects, while in the higher concentrations employed the roots were killed.[1]

Calcium hydrate and calcium carbonate added to the bottles containing aluminium or iron neutralized their injurious effects in the lower concentrations, but were ineffective with high concentrations. Calcium sulfate was entirely ineffective as an antidote.

The poisonous effects of the salts appeared to be exerted upon the tips or growing parts of the roots. The rootlets died leaving a thick, stubby taproot. Microscopic examinations of the roots by Dr. G. H. Chapman showed the cells in the growing parts to be either killed or arrested in their development.

Photographs of the clover seedlings which were published in Bulletin No. 161 are reproduced here to show the characteristic effects of the poisonous sulfates of aluminium and iron.

Culture experiments in which manganous sulfate was added to the nutrient solutions in graduated quantities were begun after it had been demonstrated that ammonium sulfate fertilization was accompanied by soluble manganese salts in the soils to which no lime had been added.

A solution of manganous sulfate, $MnSO_4.4\,H_2O$, was prepared of 1/10 molecular concentration, and measured amounts were made up to 250 cubic centimeters with the nutrient solution. Certain bottles received fine calcium carbonate and others calcium sulfate, so that the solutions in those bottles were approximately saturated with the calcium salt.

The scheme of the series is outlined below.

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[1] In preparing this bulletin it has been noted that in Bul. No. 161, by an unfortunate error in the decimal point, all figures relating to parts per million of iron in the nutrient solutions are only one-tenth as large as they should be. This error caused iron to appear much more toxic than aluminium, as compared in the tables of that bulletin.

No. 1. Standard nutrient solution.
No. 2. With calcium carbonate.
No. 3. With calcium sulfate.
No. 4. With 40 parts manganese per million of solution.
No. 5. With 40 parts manganese and calcium carbonate.
No. 6. With 40 parts manganese and calcium sulfate.
No. 7. With 100 parts manganese per million of solution.
No. 8. With 100 parts manganese and calcium carbonate.
No. 9. With 100 parts manganese and calcium sulfate.
No. 10. With 200 parts manganese per million of solution.
No. 11. With 200 parts manganese and calcium carbonate.
No. 12. With 200 parts manganese and calcium sulfate.
No. 13. With 300 parts manganese per million of solution.
No. 14. With 300 parts manganese and calcium carbonate.
No. 15. With 300 parts manganese and calcium sulfate.

The experiment was conducted outdoors in the pot yard instead of in the greenhouse, the seedlings being put under cover at night and during inclement weather. The experiment was continued four weeks.

The effect of the manganese was noticed after the first week. The seedlings with manganese did not grow as fast as the checks, and also began to show chlorosis of the leaves. The roots did not have a stunted appearance as was noticed when iron and aluminium salts were used, but seemed to be simply underdeveloped. Neither the presence of calcium carbonate nor calcium sulfate had any beneficial effect. In some cases the calcium carbonate seemed to aggravate the toxicity rather than alleviate it. When the experiment was discontinued the tops in the most concentrated manganese solutions had died and those in the most dilute had apparently lost all their chlorophyl.

The tops and roots of the plants were dried and manganese determinations were made on them. The table shows the amounts of manganese found in 1 gram of oven-dried samples.

TABLE VI. — *Milligrams of Manganese Oxide (Mn_3O_4) in 1 Gram of Clover Plants.*

	Tops.	Roots.
Standard,	None.	None.
40 ppm Mn,	2.01	17.94
100 ppm Mn,	4.56	58.80
200 ppm Mn,	5.02	83.90
300 ppm Mn,	4.41	75.31

The results show that manganese is taken up by the plants in considerable amounts and is carried into the tops. Concentrations above 100 parts of manganese per million of solution have little effect in increasing the amount taken up by the plant. While some manganese is carried into the tops, most of it remains in the roots.

In order to determine whether calcium carbonate or sulfate had any beneficial action in more dilute solutions of manganese a second experiment was undertaken. In this series 10 parts and 20 parts of manganese in a million parts of nutrient solution were, respectively, compared with the standard and with equal amounts of manganese supplemented by calcium carbonate and by calcium sulfate.

At the end of three weeks all the seedlings except those in the standard solution showed chlorosis by the light green or yellowish color of the leaves. The more dilute manganese still had a detrimental effect on the clover plants, but not so marked as in the previous experiments with higher concentrations. Neither of the calcium compounds exerted any beneficial effects, but as in the first experiment seemed, if anything, to increase the injury.

A third series of cultures was conducted during the winter in the greenhouse, and concentrations of from 10 parts to 40 parts of manganese per million of nutrient solution were again tried with and without calcium carbonate added to the solution. Much cloudy weather caused an inferior growth of the clover plants, but the experiment was continued four weeks, and at the end there was the same chlorosis of the leaves when manganese was present. Again, calcium carbonate failed to prevent the chlorosis in the presence of manganese, and instead apparently increased it.

Masoni,[1] Pugliese[2] and Aso[3] have found that iron salts seem to counteract the toxicity of manganese. In order to confirm their conclusions one series of experiments was undertaken using a combination of these two salts, another series using manganese plus aluminium salt, and still another series using iron and aluminium together.

To the standard nutrient solution were added 20 parts of manganese and 2 different quantities of aluminium, 21.6 parts and 43 parts, respectively, per million of solution, with and without calcium carbonate. A similar series was prepared containing 22 and 44 parts of iron per million, respectively.

All the solutions containing iron produced seedlings with darker color than the rest. The roots in the solutions containing aluminium or iron became stunted in appearance whether calcium carbonate was present or not. Manganese and aluminium or iron had no apparent antagonistic effects when present together in a nutrient solution.

This toxicity with calcium carbonate is unlike the results reported by McCool,[4] who found that calcium chloride would counteract the toxicity of manganese to a marked extent. This may be due to the difference in the solutions and seedlings used, as he used manganese chloride, calcium chloride and Canada field peas.

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[1] Staz. Sper. Agr. Ital. 44 (1911), p. 85; Abs. E. S. R. 26.

[2] Atti R Ist Incoragg. Napoli 6 ser. 65 (1913), p. 289; Abs. Chem. Abs. 9, p. 641.

[3] Bul. Agr. College, Tokyo, V. p. 177.

[4] Cornell Agr. Exp. Sta. Memoir No. 2 (1913).

Having found that manganese is carried up into the tops of the plants the following experiments were tried to determine if there was an increase in the amount of manganese in the tops of clover grown on plots where the poor vegetation was thought to be due to manganese.

The first crop of clover analyzed was the same as that reported in Bulletin No. 161. The tops only were analyzed, and the results were based on dry matter.

TABLE VII. — *Milligram of Manganese Oxide* (Mn_3O_4) *in 1 Gram of Clover.*

PLOT.	Fertilizer.	Limed Soil.	Unlimed Soil.
1,	Nitrate of soda,	Trace.	.076
5,	Sulfate of ammonia,	.054	.193
6,	Sulfate of ammonia,	.054	.193
7,	None,	.031	.114
8,	Sulfate of ammonia,	Trace.	.171

The clover from the limed portions of the plots shows very little difference between the different plots. The plants from the unlimed portions show a marked increase of manganese in those plots receiving sulfate of ammonia.

In the spring of 1915 samples of clover, grass, clover roots, and grass roots were taken from the limed and unlimed portions of plot 5.[1] From the unlimed end two samples were taken, one of normal looking plants and another of poor plants. The plants were brought into the laboratory and the roots carefully washed free of soil, especial care being taken not to break many of the finer roots. The tops were then cut from the roots, and the clover separated from the grass, the same being done with the roots. They were then dried at 75 degrees and ground. The tops were then analyzed for iron, manganese and silica. The roots were only analyzed for manganese as it is almost impossible to wash them entirely free from soil which would invalidate the results for iron and silica.

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[1] Plot 5 is fertilized as follows: $(NH_4)_2SO_4$, dissolved boneblack, low-grade sulfate of potash.

TABLE VIII. — *Composition of Clover and Grass Tops and Roots; in Milligrams per 1 Gram of Dry Sample.*

	Iron Oxide Fe_2O_3.	Manganese Oxide Mn_3O_4.	Silica SiO_2.
Plot 5, limed clover tops,	.63	Faint trace.	1.72
Plot 5, limed grass,	–	.053	19.25
Plot 5, unlimed good clover,	1.14	Trace.	4.82
Plot 5, unlimed good grass,	1.91	.158	26.64
Plot 5, unlimed poor clover,	1.34	.096	5.36
Plot 5, unlimed poor grass,	2.97	.272	57.35
Plot 5, limed clover roots,	–	Trace.	–
Plot 5, limed grass roots,	–	.138	–
Plot 5, unlimed good clover roots,	–	.091	–
Plot 5, unlimed good grass roots,	–	.218	–
Plot 5, unlimed poor clover and grass roots,	–	.245	–

A study of the table shows that the manganese is taken up to a greater extent by the poor plants, both clover and grass, than by the good plants. The grass seems to be more tolerant than the clover, much more being taken up than by the clover. The results would also seem to indicate that the manganese was not evenly distributed throughout the plot, but was more concentrated in spots. As it was rather difficult to find normal clover on the plot it might be said that the spots of better plants were the places of smaller amounts of manganese. A somewhat similar condition has been found by Guthrie and Cohen[1] on a golf green.

The variations in the iron content of the good and poor plants are so small as to come within the limit of experimental error. The increased amount of silica in the poor plants is probably due to their more mature state.

As the foregoing experiments with manganese salts in nutrient solutions had shown that calcium carbonate did not counteract the toxicity of the manganese, while in the field an application of lime to soil supposedly infertile because of the presence of manganese salts corrected the toxicity, pot cultures were started to determine whether calcium carbonate in the soil could counteract the toxicity of manganese.

The soil used was from the unlimed end of plot 7 and the unlimed end of plot 6. As the soil from the unlimed end of plot 6 already contained a large amount of soluble manganese it was first extracted by shaking it for two hours on a mechanical shaker with a volume of water twice that of the soil. The soil was then air-dried and passed through the large sieve (7 holes to the linear inch).

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[1] Agr. Gaz. New South Wales, 21 (1910).

Earthenware pots 6 inches in diameter and 5 inches deep were used. Each pot was filled with 2 kilos of the air-dried soil. The lime was applied to the surface and thoroughly worked in. The manganese sulfate was applied in solution. The soil was kept at a 25 per cent. moisture content. The clover seed was first soaked for eight hours in a solution of calcium hypochloride, and then seeded on the surface of the soil and pressed into contact with it. The soil was then covered with a half-inch layer of washed quartz and sand to act as a mulch. The treatment employed is shown in the table, there being two pots in each treatment.

The Series of Pot Cultures.

Pot.	Plots.	Soil Treatment.
1	Plot 6, . . .	None.
2	Plot 6, . . .	2 tons calcium carbonate per acre.
3	Plot 6, . . .	Extracted with water.
4	Plot 6, . . .	Extracted, and 2 tons calcium carbonate per acre.
5	Plot 6, . . .	Extracted, and 80 pounds manganese sulfate per acre.
6	Plot 6, . . .	Extracted, and 2 tons calcium carbonate and 80 pounds manganese sulfate per acre.
7	Plot 7, . . .	None.
8	Plot 7, . . .	2 tons calcium carbonate per acre.
9	Plot 7, . . .	80 pounds manganese sulfate per acre.
10	Plot 7, . . .	2 tons calcium carbonate and 80 pounds manganese sulfate per acre.
11	Plot 7, . . .	100 pounds manganese sulfate per acre.
12	Plot 7, . . .	2 tons calcium carbonate and 100 pounds manganese sulfate per acre.
13	Plot 7, . . .	150 pounds manganese sulfate per acre.
14	Plot 7, . . .	2 tons calcium carbonate and 150 pounds manganese sulfate per acre.

The seeds were planted on March 7 and 8, and began to show above the sand on the 9th, and most of them had sprouted by the 15th, when all the pots were watered for the first time. The plants came up rather unevenly, and some replanting was necessary. The replanting was done with seedlings sprouted on paraffine plates. On April 3 all the pots were thinned to 25 plants. The poorest pots at this time were Nos. 3 and 5, the extracted soil with and without the addition of manganese. All of the pots treated with manganese sulfate without lime were poorer than those receiving lime. On April 24 the above differences were even more striking. The plants on No. 5 had practically all died, while on No. 6, where calcium carbonate had been added, they made a small growth. All of the plants on the extracted soil were poorer than those on the other pots. The extraction had probably removed most of the soluble nutrients.

The clover was weighed in both the green and dry states, with the results given in Table IX. The crops were subsequently analyzed for total nitrogen, iron oxide, silica and manganese, the results of which are shown in Table X.

TABLE IX. — *Grams of Clover obtained from Pot Cultures.*

Pot.	TREATMENT.	Green Weight.	Dry Weight.
1	None,	8.15	1.20
2	Calcium carbonate,	22.55	3.55
3	Extracted with water,	7.00	1.05
4	Extracted, and calcium carbonate,	11.03	1.60
5	Extracted, and manganese sulfate,	5.88	.70
6	Extracted, and calcium and manganese,	17.93	2.50
7	None,	30.00	4.10
8	Calcium carbonate,	32.98	4.65
9	Manganese sulfate (80 pounds),	25.78	3.30
10	Calcium carbonate and manganese sulfate,	35.23	4.60
11	Manganese sulfate (100 pounds),	25.58	3.00
12	Calcium carbonate and manganese sulfate,	34.78	4.80
13	Manganese sulfate (150 pounds),	19.80	2.40
14	Calcium carbonate and manganese sulfate,	34.00	4.95

The soil from plot 6 was noticeably inferior in productivity to that from plot 7, when used in the pots as well as in the field. This is shown by comparing pot 1 with pot 7 and pot 2 with pot 8.

Extracting the soil with water diminished the crop, as shown in pots 3 and 4, indicating that soluble plant food was removed by the water, whether toxins were removed or not.

The addition of manganese sulfate to the soil produced a marked depression in yield on both soils when unaccompanied by calcium carbonate, while the employment of the calcium with the manganese resulted in each instance in an increase of crop beyond that produced by the calcium carbonate alone. These results are in accord with field experiments lately reported by Skinner and Reid.[1]

Chemical analysis of the clover was confined to the crops from the soil of plot 7. Manganese was found to increase in the clover tops nearly in proportion to the quantities added to the soil. The presence of calcium carbonate in the soil did not prevent the absorption of the manganese to a marked extent; therefore it would seem to have been an antidote for the poisonous effect of the manganese within the plant.

The consistent increase of the percentage of nitrogen in the crops treated with carbonate of lime is striking, and has been noted before in our field work, and reported in Bulletin No. 161.

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[1] "Action of Manganese under Acid and Neutral Soil Conditions," Bul. No. 441, U. S. Dept. Agr., 1916.

There is a singular discordance between the ill results obtained with manganese sulfate and calcium carbonate used together in water cultures and the good effects produced by their joint action in experiments with soil cultures. It is possible that in solutions the greater solubility of manganese sulfate permitted its rapid absorption by the roots in comparison with the intake of the less soluble calcium carbonate, and injurious results were produced in advance of any possible antidotal effect of the calcium.

TABLE X. — *Percentage Composition of Dry Clover from Pot Cultures.*

Pot.	TREATMENT.	Nitrogen.	Silica.	Iron Oxide.	Manganese, Parts in 1,000,000.
7	None, ...	3.04	1.03	.14	Trace.
8	Calcium carbonate, ...	3.25	1.24	.16	Trace.
9	Manganese sulfate (80 pounds), .	2.88	.71	.17	.345
10	Calcium and manganese, ...	3.73	1.74	.24	.345
11	Manganese sulfate (100 pounds), .	3.28	1.00	.20	.640
12	Calcium and manganese, ...	3.71	2.39	.29	.599
13	Manganese sulfate (150 pounds), .	3.15	.88	.19	1.157
14	Calcium and manganese, ...	3.54	2.38	.26	.893

The roots were carefully washed free of soil, dried and analyzed, but the quantities were very small and determinations could not be made in duplicate in most instances; therefore the figures have not been included here.

CONCLUSIONS.

The positive presence of soluble salts of iron, aluminium and manganese in soils which have been repeatedly dressed with ammonium sulfate without adding lime; the formation of one or more of these salts in soils that were extracted with solutions of ammonium sulfate; and the positively injurious action of manganese sulfate, iron sulfate and aluminium sulfate on seedling plants in water cultures and pot cultures when taken together form a chain of facts which clearly indicates that the injurious effects of sulfate of ammonia when used freely without the accompaniment of lime are due to the formation of these soluble salts in the soils of the fields so dressed.

BULLETIN No. 177.

DEPARTMENT OF ENTOMOLOGY.

POTATO PLANT LICE AND THEIR CONTROL.

BY W. S. REGAN.

Economic Importance of the Pest.

Potato plants among other crops have suffered severely from the attacks of plant lice during the present summer. The extent of injury has varied considerably according to the infestation. Some potato patches with a mild infestation have shown little injury, and the loss in yield from this source will be negligible. In other fields, judging from the extent to which the tops have been killed, the crop will suffer a loss of from 10 to 50 per cent., and in some instances the destruction has been so complete that it will hardly pay to harvest the crop.

The potato plant louse (*Macrosiphum solanifolii* Ashm.) is not a new insect to this section, but conditions appear to have been ideal during the spring and early summer for its multiplication to such numbers as to cause devastation in many places where no measures were taken to check it. Nor has injury by this pest been exceptional in Massachusetts this season. Reports from Connecticut, New York, New Jersey, Maryland, Virginia and Ohio indicate that the potato crop of these States has suffered equally as much; and in some of these States, in addition to killing the potato plants in many localities, these lice were becoming dangerously abundant on tomatoes. The potato crop of Maine and Canada has also been severely curtailed during some years in the past due to these pests.

In Massachusetts injury to potato plants by plant lice became evident during the second week of July, and rapidly increased in severity until the latter part of the month and early August, when no progressive injury could be noticed, and an examination of previously badly infested fields showed these insects present only in very small numbers, and certainly not numerous enough to cause further material injury this season.

This indicates a period of about three to four weeks' time when the plant lice are dangerously prevalent upon potato plants, and reports from other sections, as well as the past history of outbreaks of this pest, indicate that this is about the length of time, dating from their first appearance in injurious numbers, when damage by these insects need be feared. During this brief period potato fields showed injury varying from little to the complete destruction of the plants. Some patches were completely free from infestation, while others near by, apparently no more attractive, were badly injured or destroyed before insecticidal treatment could be applied.

The gradual disappearance of the plant lice from the potato plants, usually about a month after infestation becomes evident, has, in many cases, been the salvation of the crop. This disappearance is due mainly to natural controlling factors, such as parasitic and predatory enemies, weather conditions and disease, all of which contribute to the destruction of myriads of these insects, and to a natural migration of the plant lice from potato plants to other host plants during the latter part of July and August. These factors will be discussed at greater length later.

Description of Potato Plant Lice.

Potato lice are yellowish or greenish in color, with an occasional pink form. Some are furnished with wings and can fly readily, while others are wingless and have to depend upon crawling for getting about. When full grown these insects are no larger than a pin head, and because of their color and small size, and the fact that they occur for the most part upon the underside of the leaves, plants may be badly infested and considerable injury result before their presence is noticed.

Manner of Feeding and Nature of Injury.

Plant lice are sucking insects and obtain their food by inserting a bristle-like beak into the host plant, from which the juices are extracted. Thus all feeding is done beneath the surface and within the tissues of the plant. On plants badly attacked the leaves begin to turn yellow, curl up, gradually turn brown and die. Under conditions favoring their growth, an attack by plant lice of a week or two will suffice to kill a large portion of the top of a potato plant, and the development of the tubers must necessarily be affected on plants thus injured. When a leaf or stem becomes too dry to afford suitable feeding ground the plant lice crawl to a fresh leaf, or migrate to other plants and continue their injury.

Where plant lice are abundant enough to cause apprehension, the underside of the leaves, stems and blossom stalks will be covered with these tiny creatures, and the plants become covered with honey dew, a sticky substance excreted by these insects. This honey dew is often attacked by a black fungus, which, together with the molted skins adhering to the sticky surface, gives the plants an unhealthy appearance and undoubtedly interferes with proper functioning.

In spite of its minuteness, the beak of the plant louse makes a wound which furnishes a suitable entrance for disease, and even if the infestation with plant lice is insufficient to injure the plants, the infection with disease thus caused may entirely ruin the crop.

Life Cycle of the Potato Louse.

Numerous observations have been made on the life cycle and habits of the potato louse (Bulletin No. 147, Maine Agricultural Experiment Station), but many important details are yet to be learned. Infestation of potato plants during the late spring and early summer is accomplished by a migration of the plant lice, either by flight or by crawling from neighboring vegetation. These new arrivals are all females, and begin at once to feed upon the sap of the plants. These females lay no eggs, but in a short time produce living offspring, which are the first of a long series of females, and these likewise in the course of eight to ten days produce living young. Plant lice are prolific breeders, a single female often producing as many as 20 young per day. It is, therefore, not astonishing that they should multiply so rapidly and cause such devastation in a comparatively short time. No males or egg-laying females ever occur upon potato plants. The first few generations may be wingless, or at any time winged individuals may appear and fly away to seek fresh plants for their own feeding and for their progeny, thus causing a more or less even infestation of potato fields.

After spending a few weeks or months upon potato plants, winged individuals called "fall migrants" appear and leave the potato plants for winter hosts, — plants of the same kind as those from which the spring migration took place to the potatoes. As previously stated, the migration to the winter hosts here in Massachusetts takes place probably to some extent during the latter part of July, but mainly during August, the exact time, however, varying according to seasonal fluctuations of temperature and moisture, and the condition of the potato plants. The early drying out or dying of the potato tops will, no doubt, hasten the appearance of "fall migrants," regardless of whether the drying out is due to injury by the plant lice or to other factors.

Observations by Miss Edith Patch, State Entomologist of Maine, seem to indicate that buckwheat and shepherd's purse are among the winter hosts sought by these insects. The migration to the winter host plants is followed by the production of winged males and wingless, egg-laying females. These females lay glistening brownish black eggs upon the leaves and stalks, and in this stage the winter is passed.

Control Measures.

Practical Considerations and Fundamentals of Control.

Under the topic "Manner of Feeding and Nature of Injury," discussed on an earlier page, it was pointed out that plant lice obtain their food by piercing the host plant and sucking the juices from within, no feeding being done on the outer surface. Therefore any poison, such as arsenate of lead or Paris green, which is sprayed over the foliage and must be eaten in order to be effective, would be absolutely useless against plant lice, since these insects pierce beneath the poison before feeding is begun. Accordingly, a contact insecticide, a material which kills by contact with the body, is required to deal effectively with these sucking insects, and satisfactory results with an insecticide of this nature can be expected only when application is absolutely thorough. *Each insect must be hit by the spray* in order to be killed. Careless work will merely lead to a waste of material, time and energy and to a continuation of the infestation. Such carelessness, frequently due to ignorance of the essentials of application rather than intent, is often the source of complaint that material recommended for the control of plant lice is ineffective. Almost invariably unsatisfactory results with standard contact insecticides are attributable to improper application. Since potato lice confine their feeding almost wholly to the underside of the leaves, care must be taken to direct the spray upward so that the underside of each leaf will be well covered.

To apply such a spray before the infestation reaches the distinctly dangerous stage, while it might kill many of the scattered plant lice, might, on the other hand, be merely a waste of energy, for the amount of injury which the plant lice are going to inflict is purely problematical, so many elements of uncertainty enter in. For instance, weather conditions play an important part in the welfare of the plant lice. Heavy rains wash these delicate insects from the plants, and cold weather retards their increase. Warm, damp weather is favorable to a parasitic fungous disease which may destroy the plant lice over large areas. Parasitic and predatory enemies, when conditions are favorable, often destroy such numbers of the plant lice, even after considerable injury to the plants is evident, that control measures are superfluous. Then, too, the natural migration of the plant lice from potato plants to the winter hosts is an element of some uncertainty. The greater amount of injury may be completed and the plant lice soon be ready to leave the potato plants for the winter hosts before injury to the vines is extensive enough to become particularly noticeable. At this time, if the fact were known, it would hardly appeal to the average grower as an economical proposition to institute control measures.

All of these factors combine to make the matter of the desirability or necessity of artificial control measures for potato plant lice often a difficult one to determine. Furthermore, it has been the observation of the writer that in many cases where control measures have been carried out, particularly where improper application made several sprayings necessary, more actual injury was done the plants by the handling and trampling incidental to such work with a contact insecticide than, it is probable in most cases, the plant lice would have inflicted had the infestation been allowed to run its course.

One application with the proper material, properly applied to the underside of the foliage, when the infestation is severe enough to cause evident wilting of the leaves, can in most cases be made economically and to advantage, especially if injury is noticeable before the early part of

August, when the infestation is more likely to be progressive than otherwise. This is especially the case with the average garden potato patch. Over larger areas the practicability of applying treatment must be determined by the severity of the infestation, its seasonal importance, — that is, whether it is liable to be progressive or is past the dangerous stage, — accessibility, available apparatus, etc.

Reference has already been made to the fact that the winter is passed in the egg stage of the plant louse upon such plants as buckwheat, shepherd's purse and possibly various other weeds. On this account "clean culture;" the destruction by burning of potato vines, weeds and other refuse about gardens and potato fields after harvest, unless such material is composted; the burning over of grassy and weedy fields in the vicinity of potato patches in the late fall or early spring; and late fall plowing of gardens are worthy of more general practice.

The increased danger to the potato crop from "blight" after infestation with potato lice has already been pointed out. This should emphasize the need of frequent spraying with Bordeaux mixture or similar fungicide for the remainder of the growing season.

Efficiency of Various Contact Insecticides for the Control of Potato Lice.

During the early part of July, when injury by potato lice began to cause considerable apprehension, many conflicting reports were received concerning the efficiency of different contact insecticides recommended for the control of these insects. On this account, as well as from the fact that the demand at this time for nicotine sprays so exceeded the supply in many localities that it was impossible to obtain this material, it was thought desirable to have at hand some more definite knowledge concerning the effectiveness of the various common contact sprays, in order to be better able to recommend a substitute where any material desired was unobtainable.

With this end in view a badly infested potato field, already showing severe injury to the tops, due to the sucking of the plant lice, was selected to carry out these trials, which were conducted by Mr. A. I. Bourne of the Massachusetts Agricultural Experiment Station staff and the writer. All plants treated were thoroughly drenched, the under and upper sides of the foliage alike, and carefully tagged, check plants being left for comparisons. It must be kept in mind that a satisfactory contact insecticide combines safety and efficiency with reasonable cost. It must be strong enough to kill the insects and yet not injure the foliage of the plant to which it is applied, and the cost of application must not be excessive. It will be seen from the following report on these experiments that only a comparatively few dilutions of the materials tried met this test. It was impossible, in most cases, to make a very accurate estimate of the percentage of plant lice killed, so that where a percentage estimate is given it is intended to show the comparative efficiency of the various insecticides tried, and is at best only roughly approximate. It is hardly to be expected that the spraying operations of the average grower will result as successfully as those reported here, where all possible care was taken to thoroughly drench the plants.

It should be kept in mind, however, that it is only necessary to reduce the numbers of the plant lice 75 per cent. or more, when they can no longer continue an aggressive attack that will result in serious injury, but must take, figuratively speaking, a defensive position against their enemies. The parasitic and predatory enemies of the plant lice are much more resistant to contact sprays than the plant lice themselves, and in no case with the insecticides used where the plants were not injured were these beneficial insects destroyed, although they were present in numbers when application was made. The few plant lice which escape an efficient spray application fall ready prey to these enemies. A report of the results of these tests follows: —

MATERIAL AND DILUTION.	Plant Lice killed.	Injury to Plants.
"Black Leaf 40" (1–400) with soap, .	99–100 per cent., . . .	No injury.
"Black Leaf 40" (1–800) with soap, .	98–99 per cent., . . .	No injury.
"Black Leaf 40" (1–800) with Pyrox, no soap.	98 per cent., ...	No injury.
"Black Leaf 40" (1–1,000) with soap, .	Not over 75 per cent., . .	No injury.
"Black Leaf 40" (1–1,600) with soap, .	Ineffective, few killed, . .	No injury.
"Nico-Fume" liquid (1–750) with soap,	98 per cent., ...	No injury.
Fish-oil soap (1–5), ...	98–99 per cent., . . .	No injury ?
Fish-oil soap (1–6), ...	98 per cent., ...	No injury.
Fish-oil soap (1–8), ...	Not over 50 per cent., . .	No injury.
Kerosene emulsion (1–9), . . .	90 per cent., ...	No injury.
Miscible or soluble oil (1–25), . .	Perfect kill, ...	Plants killed.
Miscible or soluble oil (1–40), . .	Perfect kill, ...	Considerable injury.
Miscible or soluble oil (1–50), . .	98–99 per cent., . . .	Some injury.
Miscible or soluble oil (1–64), . .	98 per cent., ...	Some injury.
Lime-sulfur, 34° Beaumé (1–22), . .	Ineffective, not over 20 per cent.,	Some injury.
Lime-sulfur, 34° Beaumé (1–43), . .	Ineffective, ...	No injury.

Discussion of Results.

1. *"Black Leaf 40."* — This material is perhaps the insecticide most commonly used for the control of plant lice, but any of the other nicotine preparations of a similar nature now on the market should give satisfactory results. It is a concentrated solution of nicotine sulfate, containing 40 per cent. of nicotine by weight. It was tried with four dilutions — 1–400, 1–800, 1–1,000, and 1–1,600 — in each case, with the addition of soap at the rate of 2 pounds to 50 gallons of the diluted "Black Leaf 40." Both ordinary hard laundry soap and liquid soap were used with similar

results, the hard soap being cut into small pieces and dissolved in boiling water before adding to the solution. If liquid soap is used, 1 quart should be added to every 50 gallons of the diluted "Black Leaf 40." In addition to increasing the effectiveness of this nicotine preparation the soap aids materially as a spreader, thus insuring a more uniform coating of the foliage and a more perfect "hit" of the plant lice.

All of the four dilutions tried showed no foliage injury, but only the 1–800 strength met the test of reasonable economy and efficiency. This strength showed nearly a perfect kill.

The dilution 1–800 reduced to practical terms is as follows: —

"Black Leaf 40,"	½ pint.
Hard soap, dissolved in boiling water,	2 pounds (liquid soap, 1 quart).
Water,	50 gallons.

Reduction to a small amount would be as follows: —

"Black Leaf 40,"	1¼ teaspoonfuls.
Hard soap, dissolved in boiling water,	⅔ ounce.
Water,	1 gallon.

The cost of this spray material will depend mainly upon the quantity of the "Black Leaf 40," or similar nicotine preparation, purchased. In an amount of 10 pounds, which diluted as recommended (1–800) would give 1,000 gallons of spray mixture, the cost amounts to but little over 1 cent per gallon. If purchased in an amount as small as an ounce the cost is increased to something over 4 cents a gallon.

2. *"Black Leaf 40" and Pyrox, etc.* — The question has frequently been asked as to whether or not "Black Leaf 40" can be safely combined with Pyrox, Bordo-lead and other materials, such as arsenate of lead and Bordeaux mixture, thus reducing the labor involved in making separate applications. Pyrox and Bordo-lead are a combination of an arsenical and a fungicide, and are used for the control of leaf-eating insects, such as the potato beetle, and fungous diseases. "Black Leaf 40" and Pyrox or Bordo-lead can be safely combined with equally as good results as when these materials are used separately. However, *soap should not be used* with such a combination, and should never be used in any combination containing Pyrox, Bordo-lead or Bordeaux mixture, as an "incompatible mixture" results. "Black Leaf 40," or any similar nicotine preparation, may also be safely combined with arsenate of lead or Bordeaux mixture — but without the addition of soap.

3. *"Nico-Fume" Liquid.* — This material is somewhat similar to "Black Leaf 40," being a nicotine preparation containing 40 per cent. free nicotine. There appears to be little or no difference in the effectiveness of these two materials, and since the "Nico-Fume" liquid is the more expensive, it is suggested merely as a possible substitute in case the "Black Leaf 40" is not obtainable. It was used at approximately the same strength as the "Black Leaf 40," and with the addition of a like

amount of soap. Combinations of "Nico-Fume" liquid with other insecticides and fungicides can be made with the same restrictions as for "Black Leaf 40."

4. *Fish-oil or Whale-oil Soaps.* — These soaps have long been used for the control of plant lice. Three dilutions were tried, — 1 pound to 5 gallons of water, 1 pound to 6 gallons of water, and 1 pound to 8 gallons, the soap being cut up into small pieces, dissolved in boiling water, and diluted with cold water to the required strength. The 1–5 and 1–6 strengths showed high efficiency. The 1–8 strength was unsatisfactory, not more than half of the plant lice being killed. There was some suspicion of foliage injury at the 1–5 strength, but this was not extensive, and, since some of the tops had been killed by the plant lice, this point could not be definitely determined. The 1–6 strength proved efficient and showed no injury. Used at this strength the cost of fish-oil or whale-oil soap spray is approximately that of the "Black Leaf 40" solution, 1–800; that is, less than 2 cents per gallon where a quantity of the soap to the amount of 5 pounds or more is purchased. Since the amount of soap to be dissolved in case the fish-oil or whale-oil soap is used is greater than the quantity used with the "Black Leaf 40" solution, the latter is perhaps somewhat preferable because of the smaller outlay of time and bother thus involved. These soaps, however, furnish an excellent substitute in case of difficulty in obtaining the nicotine preparation. Pyrox, Bordolead, Bordeaux mixture or similar materials should never be used with soap of any kind.

5. *Kerosene Emulsion.* — This material was made according to the usual stock formula, as follows: —

Hard soap, ...	½ pound (liquid soap, ½ pint).
Water, ...	1 gallon.
Kerosene, ...	2 gallons.

The soap is cut into small pieces and dissolved in the water, which should be boiling. The soap solution is then poured into the kerosene while hot, and churned back and forth with a spray pump until a creamy mass is formed and no free oil is present. This can usually be done satisfactorily in from ten to fifteen minutes. The emulsion formed is a stock solution, which should be diluted at the rate of 1 part to 9 parts of water for plant lice.

It was supposed that kerosene emulsion, a standard remedy for plant lice and other soft-bodied insects, would prove highly effective against potato lice, but the trials with this material proved disappointing, as not more than 90 per cent. of the insects were killed. This indicates an efficiency for kerosene emulsion considerably less than that of the "Black Leaf 40," 1–800, and the fish-oil soap, 1–6. Furthermore, the trouble and time involved in making the emulsion, as well as the danger of foliage injury when this material is improperly made, militate against its use where the other materials referred to above are obtainable. The cost of the kerosene emulsion per gallon of the diluted spray is something over 1 cent, or approximately the same as for the "Black Leaf 40" and the fish-oil soap solutions.

6. *Miscible or Soluble Oils.* — One of the standard commercial brands of miscible oils was used in these tests, this being tried with four dilutions, — 1–25, 1–40, 1–50 and 1–64. This material in all four dilutions showed a very high killing efficiency, but even at the greatest dilution, 1–64, showed distinct oil injury to the potato foliage. In justice to this material, however, it must be said that the sample experimented with was not perfect, as there was some free oil evident, an ever-present danger, nevertheless, with this material. Time did not permit obtaining a fresh sample of miscible oil, so that this material must be placed in the questionably dangerous class until further experiments prove to the contrary. The cost of this material is less than that of any of the other insecticides referred to, and obtained in any quantity would amount to less than 1 cent per gallon of diluted spray material.

7. *Lime-sulfur.* — A standard commercial brand of this material, having a density of 34 Beaumé, was used in these tests. Two dilutions were tried, — 1–22, which is about twice the normal strength for application to foliage, and 1–43, which is about the usual dilution for foliage spraying. Even at the 1–22 strength this material killed only a comparatively small number of plant lice, and could in no way be considered an effective aphidicide. Furthermore, at this strength there was evident foliage injury shortly after application, which took the form of a wilting or drooping of the plants. The next day, however, the plants thus injured seemed to have entirely recovered.

Spraying Apparatus.

Satisfactory spraying outfits for applying insecticides are equally as important as efficient spray materials. Ordinary hand atomizers are useless, since it would be necessary to turn over every plant so that the underside of the leaves could be reached. Such handling would probably result in as much injury to the plants as the plant lice would be likely to inflict. For small garden potato patches, perhaps up to a quarter of an acre, a knapsack or compressed-air spray pump will prove satisfactory. These pumps hold from 3 to 5 gallons of spray, but the frequent need of refilling makes them less desirable for use where larger areas are to be treated. In spraying operations involving fairly large potato fields a barrel pump, traction outfit, power sprayer or similar apparatus will be found the only practicable thing.

Regardless of the type of pump used, an extension rod and an under-spray nozzle at a right angle to the rod are essential in order that the underside of the leaves may be easily reached. For a knapsack or compressed-air pump a 3 or 4 foot extension rod of iron or brass is perhaps most convenient. A 4 or 5 foot length of iron pipe is, perhaps, most satisfactory when directing the spray by hand from a barrel pump, power sprayer or similar apparatus, but numerous combinations of rods and nozzles may be made to increase the spraying area or the number of rows treated at one time. In the case of traction sprayers or other direct row-spraying apparatus the common inverted T method is ordinarily used with two nozzles attached to throw spray in opposite directions, so that two rows may be treated from each T. By attaching several T's to the main cross rod, so that the T's come between the rows, a number of rows may be sprayed simultaneously. It is essential with such apparatus that the T's be made sufficiently long and the nozzles attached at the proper angle to thoroughly drench the underside of the foliage. Work with such apparatus must be done slowly if satisfactory results are to be expected. Some growers have adopted an arrangement with traction sprayers whereby a cross piece, located a short distance in front of the nozzles, tips over the plants. The nozzles are directed forward and downward so that, theoretically, while the plants are thus tipped over, the underside of the leaves are covered with the spray. Not only is the efficiency of this method open to doubt, but the effect upon the plants of such treatment is worthy of consideration.

A nozzle giving a fine mist spray is essential. The disk and Vermorel are two types of nozzles well adapted for the work. The disk nozzle must be of the *angle form*, which gives a suitable underspray at a right angle to the rod, and covers a fairly large area, being on this account preferable to the Vermorel nozzle. The Vermorel nozzle cannot be purchased in the angle form, but a 45° elbow can be obtained or a bend made in the extension rod to overcome this difficulty. It is fairly well adapted for use with a knapsack or compressed-air pump.

Where a considerable length of hose is needed it is desirable to have this as light as possible in order to facilitate handling among the rows with the least possible injury to the plants. One-fourth inch Meruco tubing has been found highly satisfactory for this purpose, especially for the leading hose. Attachments for this tubing to rubber or cotton hose of larger size can be readily obtained. Long-tail hose couplings will also be found advantageous in preventing a "blow-out" where pressure of any amount is used.

SUMMARY OF CONTROL MEASURES.

1. Potato plant lice can be readily controlled by the use of a contact insecticide of "Black Leaf 40" or similar nicotine preparation at the rate of 1 part of this material to 800 parts water, with the addition of common laundry soap, dissolved in boiling water, at the rate of 2 pounds (liquid or soft soap, 1 quart) to 50 gallons of the diluted "Black Leaf 40" solution. The formula in practical terms is given on an earlier page.

Fish-oil or whale-oil soap at the rate of 1 pound to 6 gallons of water is about equally as effective, but is less desirable on account of the extra time and bother involved in dissolving larger quantities of soap.

"Black Leaf 40" can be combined safely with Pyrox, Bordo-lead, Bordeaux mixture or arsenate of lead, but soap should be omitted when such combinations are made. These combinations are equally as effective as when the materials are used separately.

Kerosene emulsion is not highly effective against potato plant lice, and the labor involved in preparing this material is also against its use.

Tests with miscible or soluble oils seem to indicate that these materials are dangerous to use upon potato foliage.

Lime-sulfur is ineffective for the control of potato plant lice even at double the ordinary strength used upon foliage.

2. Satisfactory results with an efficient contact spray can be expected only when thorough work is done. *Each insect must be hit with the spray.* Since plant lice confine their work almost wholly to the underside of the leaves, the spray must be directed upward from underneath the plants. An *angle disk* nozzle or similar underspray nozzle is necessary for such work. One thorough application with an efficient spray should control potato plant lice so that a second treatment will be unnecessary. Too much handling or trampling about the plants will often result in more injury than the plant lice are likely to cause.

3. The practicability of applying treatment for the control of potato lice, especially over large areas, must be determined by the severity of infestation, its seasonal importance, — that is, whether it is likely to be progressive or is diminishing in severity, — accessibility, available apparatus, etc. If injury to the plants has not been severe enough to kill portions of the tops of the plants to an evident extent before the 1st of August, it is probable that the injury likely to be done will not exceed the cost of applying treatment. When severe injury is noticeable before the 1st of August, a thorough treatment should be made *at once.* Application before the insects are present in numbers will be merely a waste of time and energy.

4. The destruction by burning of potato vines after harvest, together with all weeds and other refuse about gardens and potato fields, unless such material is composted; the burning over of grassy and weedy fields in the vicinity of potato patches in the late fall or early spring; and late fall plowing of gardens are methods of clean culture which may materially reduce future infestation.

5. Injury by potato lice renders the plants more susceptible to "blight," and should emphasize the need for frequent sprays with Bordeaux mixture.

Natural Agents in the Control of Potato Plant Lice.

Many factors contribute to a natural control of potato lice; in fact, to such an extent that during most seasons in the past their injury has been unimportant in Massachusetts.

Weather conditions rank very high among controlling influences. Cool or wet weather offers quite a decided check to aphid development, and heavy or continuous rains undoubtedly destroy many of these delicate insects.

Among the predatory enemies of plant lice, lady beetles and their young, and the larvæ of syrphus flies, are most important. Both as adults and during the immature stages, lady beetles are voracious feeders upon plant lice as well as upon other tiny insects. The average person readily recognizes a lady beetle and knows its beneficial habits, but the lady beetle young, being of an entirely different appearance, are often mistaken for injurious forms and unfortunately are destroyed. These young vary in length all the way up to about a half inch, are bluish or blackish in color, often with orange spots on the back, and resemble very much a miniature alligator in general appearance. They crawl about freely, destroying large numbers of the plant lice. The syrphus fly young are maggot-like forms, being pointed at the head end and somewhat broader behind, and are of variable length but average about one-fourth of an inch. These are ordinarily orange, greenish or whitish in color, are very sluggish, but destroy, nevertheless, numbers of the plant lice.

Tiny, almost microscopic, wasp-like insects also aid in the destruction of plant lice, their young living parasitically in the bodies of these pests.

During certain seasons, especially when there is an abundance of warmth and moisture, a fungous parasite attacks these plant lice and destroys large numbers. In some localities this disease has been credited with having practically exterminated the plant lice after they had become numerous enough to menace seriously the potato crop.

Acknowledgments.

The foregoing is not presented as a "distinct contribution to scientific knowledge," but is merely an attempt to present in available form facts already determined by others, together with results of personal observations and experience.

The writer wishes to acknowledge credit to Bulletin No. 147, Maine Agricultural Experiment Station, for certain facts and suggestions made use of in this paper; and is indebted to Mr. A. I. Bourne of the Massachusetts Agricultural Experiment Station staff for assistance in carrying out the insecticide tests.

The work has been carried out under the direct supervision of Dr. H. T. Fernald, whose kind co-operation has been of much help.

BULLETIN No. 178.

DEPARTMENT OF ENTOMOLOGY.

THE EUROPEAN CORN BORER,

Pyrausta nubilalis Hübner,

A RECENTLY ESTABLISHED PEST IN MASSACHUSETTS.

BY S. C. VINAL.

Nearly every year we find a new insect pest of foreign origin has become established in some section of the United States. To the long list of European pests now found in Massachusetts this article adds one more, — the European corn borer or corn pyralid, *Pyrausta nubilalis* Hübner, recently established in the vicinity of Boston, Mass. This species has long been recorded as one of the most serious enemies to maize culture in Europe, and if not checked may in time become a very serious pest to America's great corn crop.

Discovery and Identification.

During the past summer the writer found many corn plants in the vicinity of Boston, Mass., being tunneled by light colored caterpillars, the identity of which was unknown. During July nearly every infested plant could be readily detected, having its tassel broken over and hanging pendent just above the first two or three spikes. This was due to the larval tunnels in the pith of the main tassel stalk so weakening it that the wind readily blew it over.

Early in August moths emerged from pupæ collected in the field, and having Dr. C. H. Fernald's collection of both native and exotic moths available, a successful attempt was made to determine the species. Specimens of both male and female pyralid moths which corresponded identically to those obtained from infested corn stalks in eastern Massachusetts were found in his European collection. These were determined by M. Ragonet, a French lepidopterist, and were labeled *Pyrausta* (Botys) *nubilalis* Hübner. Further proof of the identity of this moth was obtained by submitting specimens to Mr. H. G. Dyar of the United States National Museum, Washington, D. C., who determined them to be *Pyrausta nubilalis* Hübner, a native of Europe.

Description of the Insect.

When full grown the larva is 1 inch in length; the body is flesh-colored, often somewhat smoky or reddish above, while the head is flat and dark brown in color. On close observation a transverse row of four light colored spots, with two smaller ones immediately behind them, can be seen on each abdominal segment. From each of these light colored areas a short, stout spine arises, and this character distinguishes the European corn borer from the mature caterpillar of the potato and corn stalk borer (*Papaipema nitella* Gn.).

The female moth has a robust body, is pale yellow in color and has a wing expanse of a little over 1 inch. The outer third of the fore wing is traversed by two serrated lines darker than the rest of the wing, while the hind wings are light yellow in color.

The male moth has a long, slender body, is slightly smaller in wing expanse, and in color is reddish brown, being much darker than the female. Between the two serrated lines mentioned above is a pale yellow streak, and near the middle of the fore wing are two small yellowish spots. The hind wings are grayish and crossed by a broad band of pale yellow.

European History.

Pyrausta nubilalis is widely distributed in Europe and Asia, having been reported in literature as occurring in Central and Southern Europe, West Central and Northern Asia and Japan. Its food plants in these widely separated localities consist of corn (except fodder corn), hemp, hops, millet and several wild grasses. Corn and hop plants are severely damaged by this pest, 50 per cent. of these crops being destroyed in some sections of Central Europe.

Foreign literature contains a large number of references to the serious damage caused by the larvæ of *P. nubilalis*, but there is a decided lack of literature dealing with its biology and control.

Status of the Pest in Eastern Massachusetts.

Importation.

The questions naturally arise as to how, when and where the European corn borer was introduced. At the present time these cannot be definitely answered, but a few deductive conjectures may be given.

The important European food plants of *P. nubilalis* consist of corn, hemp, hops and millet. Of these the only food plant offering ideal conditions for its importation is hemp. This crop is grown to some extent in Southern Europe, and probably some plants infested by larvæ of *P. nubilalis* were cut and shipped during the fall and winter months to a cordage company in the vicinity of Boston, Mass. These plants were not used immediately, and the larvæ transformed to pupæ in early spring, and soon emerged as moths. On finding corn plants growing in the vicinity, oviposition took place and the European corn borer became established.

Early sweet corn grown in market gardens 10 to 12 miles inland has been seriously attacked by this pest for the past three or four years, and from this we might infer that it was imported about 1910.

A survey of eastern Massachusetts showed that some towns located at the mouth of the Mystic River were more generally infested than others. At the mouth of this river is located the Charlestown Navy Yard, which probably has one of the largest "rope walks" in Eastern United States. Whether the European corn borer was first introduced at the Navy Yard, or at some cordage company located on the opposite bank of the river, it has been impossible to ascertain, but enough has been written to show that it probably was first established in this vicinity.

Present Distribvtion.

The area infested by the European corn borer in Massachusetts is approximately 100 square miles in extent, and is located immediately north and northwest of the city of Boston. The places most severely infested during the past season were Somerville, Medford, Malden, Everett, Chelsea, Revere, Lynn, Saugus, Melrose, Stoneham, Winchester, Arlington, Belmont, Cambridge, Brookline and the following parts of Boston: South Boston, Brighton, Roxbury and Dorchester.

Food Plants.

At the present time sweet corn is the only valuable commercial crop seriously attacked by this pest, for the other food plants — hops, hemp and millet — are not grown within the infested region of Massachusetts. The most commonly infested weeds and grasses are barnyard grass (*Echinochloa crus-galli* Beauv.), pigweed (*Amaranthus retroflexus* L.) and foxtail grass (*Setaria glauca* Beauv.). Dahlia stems are also injured by the European corn borer. The moths apparently prefer to oviposit on corn, and will not infest weeds and grasses unless corn plants are not available in sufficient numbers.

Importance.

Sweet corn is practically the only corn grown within the infested area, and the amount of damage caused by the European corn borer depends upon whether it is an early or late variety. The early crop of sweet corn is picked during late July and early August, and by reference to the life history it will be seen that these plants are subjected to the attack of the first brood of larvæ only. The late corn, however, suffers from the attack of both the first and second broods of larvæ. While the early crop may be damaged to the extent of 10 to 20 per cent., the loss to late corn plantings may be as high as 75 to 80 per cent. This higher percentage of damage to late corn is caused by the habit of the small second brood larvæ of boring through the husk and tunneling in the developing ear, making it worthless for market.

Character of Injury.

With the exception of the leaf blades the whole corn plant above ground is subject to the attacks of these voracious caterpillars.

The larvæ after emerging from the egg either commence feeding on the unopened staminate flowers borne by the tassel, or immediately pierce the sheath near its junction with a node. Those which feed on the tassel bore a hole in the side of the buds and feed on the internal succulent parts. Soon these small caterpillars leave the tassel buds and enter the tassel stalks, or terminal internode, where they tunnel through the pith and finally complete their larval life in this internode. These tunnels so weaken the terminal internode that it soon becomes broken over, a type of injury which is especially noticeable on the early corn crop. It is quite evident that this injury indirectly affects the formation of corn on the cob by destroying the pollen necessary for fertilizing the corn silk.

Those larvæ which do not feed on the tassel immediately pierce the sheath surrounding an internode, usually where the edges overlap at its junction with a node. Here they feed on the internal surface of the sheath, excavating a groove halfway around the stalk, and then bore directly into the pith where they form long winding tunnels. Whenever the larvæ during their tunneling operations reach a node, a rather large cavity is usually formed. From this cavity the larvæ sometimes bore through the node, but more often they turn and tunnel in the opposite direction in the originally infested internode. At the termination of the feeding period nearly all of the central portion of the stalk has been eaten, and this so weakens the plant that a strong wind is likely to break over the stalk, thus completing the destruction commenced by the caterpillars.

A number of these stalk-boring larvæ very often attack the small stalk or pedicel bearing the ear, and in some cases may bore directly through this into the developing ear. This injury to the pedicel causes the ear to wither and die.

The most serious damage to the crop is caused by the large percentage of the second brood larvæ which immediately enter the ear after hatching. The injury by this brood to the corn ear is very similar to that caused by the well-known corn ear worm (*Chloridea obsoleta* Fab.). Besides feeding on the kernels in a similar manner to the corn ear worm, the European corn borer exhibits characteristic tunneling habits and bores through the cob.

Life History and Habits.

As the life history has not been thoroughly worked out, it is only possible to give a brief résumé of it at the present time.

There are two broods a year of the European corn borer. Hibernation takes place as full grown or nearly full grown larvæ, within their tunnels in the corn stalks, and in some cases in the cob. These larvæ pupate in the spring and emerge as moths, probably the latter part of May. Soon after emergence the females begin laying eggs on the corn stalks, and in a few days these hatch. The young larvæ begin feeding at once, and quickly eat their way through the sheath before they tunnel in the main stalk.

On reaching maturity, which occurs the latter part of July, the larvæ clear out a portion of the burrow, prepare an opening through which the adults can escape, and after spinning a thin silken partition across the top and bottom of this cleared space, transform to pupæ. The moths emerge for the second brood in about two weeks. This brood of larvæ becomes full grown by late fall, but does not transform to pupæ at once as in the first brood. Instead, the winter is passed as larvæ within the stalks, pupation taking place the following spring.

Control.

From the brief sketch of the life history it is apparent that there is no hope of destroying this pest during the summer by the use of insecticides, since all of its transformations take place *within* the plant. Our main hope lies in the possibility of establishing a system of cultural methods which will enable us to *prevent* injury. The fact that the winter stage is passed in the food plant suggests control measures which should result in killing the great majority of the hibernating insects. These measures, if carefully followed, should reduce the injury of the following season materially.

1. *Burning the Stalks during the Fall or Winter.* — While this is undoubtedly one of the most effective measures for the destruction of the hibernating insects which can be adopted, it is somewhat wasteful, for the stalks are valuable either for feed or as a source of humus so necessary for maintenance of fertility and texture in the garden soil. Burning, therefore, is inadvisable when other effective methods can be used.

2. *Burying the Stalks.* — In home gardens the stalks may be put in trenches and covered by at least 1 foot of soil. In larger market gardens the stalks may be placed in the center of manure piles until decomposed. In some cases plowing under might be resorted to, but the work must be thorough or it will be ineffective. Any stalks left on the surface are likely to harbor a crop of borers for the next season. If corn stalks are distributed over the land and then cut up by running a disk harrow over the field in both directions it should be possible to turn them practically all under.

It should be clearly understood that half-hearted work is of little value. Occasional stalks which it may seem hardly worth the trouble to clean up are likely to harbor enough borers to severely infest the spring crop.

3. *Feeding the Stalks.* — From the economic point of view this is the best possible means of destroying the hibernating insects, since the value of the stalks for fodder is not materially affected by the presence of the insects, and if properly carried out this method must result in the destruction of practically all of them. Feeding the stalks whole will be relatively ineffective, since parts not eaten by the animals are likely to harbor insects. Shredding the stalks, whether to be fed green or dry, must greatly

reduce the chances that any of the insects will survive. Ensilage by ordinary methods must prove a highly effective method of destroying the insects present in the stems or other parts of the affected plants, for it would seem to be in the last degree improbable that they could survive under the conditions existing in the silo.

Co-operation.

It has been pointed out that the caterpillars which survive the winter emerge as moths which fly freely the following spring. Consideration of this fact makes it apparent that no method of control can be even fairly satisfactory unless all those cultivating corn in an infested district co-operate to insure as far as may be possible the destruction of all hibernating insects. A few neglected gardens in any vicinity may harbor enough borers to infest a wide area.

Measures for insuring or compelling satisfactory handling of all infested material are, therefore, very necessary, and, while the desired end might possibly be obtained by local organizations of farmers and gardeners and vigorous action, it seems probable that the matter must be taken in hand by the State or Federal government if the insect is to be brought under control.

BULLETIN No. 179.

DEPARTMENT OF ENTOMOLOGY.

THE GREENHOUSE RED SPIDER ATTACKING CUCUMBERS AND METHODS FOR ITS CONTROL.

(*Tetranychus bimaculatus* Harvey.) (Class, *Arachnida;* Order, *Acarina;* Family, *Tetranychidæ.*)

BY STUART C. VINAL.

INTRODUCTION.

The minute spinning mites, commonly called red spiders, have long been known as among the most troublesome of greenhouse pests, although they also cause a great deal of damage to flowers, vegetables and trees growing out of doors. A greenhouse affords an almost ideal environment for the development and rapid multiplication of red spiders, and as a consequence we find this pest taking advantage of the opportunity offered and doing great damage to many of the principal crops grown in greenhouses.

The production of vegetables under glass is an expensive process, involving a large investment of capital and a continual expense to maintain such an establishment. To counterbalance this expense the value of the crop must be proportionally high, and anything which interferes with the fullest development of the plants reduces the profits materially.

Without doubt the common red spider (*Tetranychus bimaculatus* Harvey) is the most widely distributed and destructive pest of greenhouse cucumbers. Nowhere in America is the cucumber forcing industry more highly developed than in the market-garden district of Boston, Mass., and therefore the injury caused by this pest assumes its greatest economic importance in this section.

During the last few years numerous inquiries have been received by the Massachusetts Experiment Station from market gardeners in regard to the control of red spiders attacking greenhouse cucumbers. Because of the lack of an efficient method of control very few recommendations could be given, and in many cases the injury by these mites resulted in serious losses. Thus it soon became evident that some line of investigation should be conducted on the control of this mite attacking greenhouse crops, and in October, 1915, this problem was assigned to me.

The investigations upon which this paper is based were carried on under the direct supervision of Dr. H. T. Fernald. The thanks of the writer are due Dr. H. T. Fernald, Dr. G. C. Crampton and Dr. W. S. Regan for their interest throughout the progress of the work. Acknowledgments are also due the chemistry department of the station for its co-operation, expecially to Dr. E. B. Holland for his interest and careful manufacture of many complicated spray materials which led to the discovery of an efficient control for the greenhouse red spider. The writer is also under obligations to Mr. H. F. Tompson, professor of market gardening, for suggesting this research and for much valuable information concerning the efficiency of control measures when used in commercial houses. To Mr. M. E. Moore of Arlington and Mr. J. Winthrop Stone of Watertown the writer gratefully acknowledges his indebtedness for their kind co-operation in allowing promising materials to be thoroughly tested on a commercial scale in their greenhouses.

As this paper has to deal primarily with the control of the greenhouse red spider, other more biological phases will be discussed only briefly, unless they have a direct bearing upon control measures.

HISTORY AND DISTRIBUTION.

The greenhouse red spider of New England was first described by Harvey in 1893 as *Tetranychus bimaculatus*. He considered it distinct from the European species *Tetranychus telarius* Linn., and later workers have failed to prove conclusively the identity of these species.

The first account of serious injury caused by this mite in the United States came from the New England States, where it caused much damage to greenhouse plants. In 1855 a mite, since described by Banks as *T. gloveri*, but now known as *T. bimaculatus* Harvey, was reported by Glover as doing injury to the cotton plants of the south. This injury increased in importance, and in 1900 the Bureau of Entomology, United States Department of Agriculture, established a southern laboratory to work on the control of this pest. With the development of greenhouses in the west the ravages of the red spider soon appeared and caused serious damage to greenhouse plants as well as to many cultivated garden plants and fruit trees. A closely related mite has long been a serious pest of hop plants in Europe; therefore it is not surprising that our species of red spider assumes a great importance in seriously damaging hop fields both in the east and far west.

The red spider, therefore, is very generally distributed throughout the United States, extending from Maine to Florida and westward to Texas and California, only a few States in the western arid region being exempt from the ravages of this pest.

FOOD PLANTS.

Tetranychus bimaculatus is very cosmopolitan in its feeding habits, having been listed by McGregor as feeding on 183 species of plants, 55 per cent. of which were cultivated, in the southeastern part of the United States. Much confusion has arisen because of the large number of host plants and the variability in color of mites feeding on these different plants. New species have been described based upon these color variations, but they have been discarded by later workers as synonymous.

Under New England conditions of climate the red spider as a rule does not seriously damage plants except those which are usually grown in greenhouses. A few exceptions to this statement may occur near badly infested greenhouses or during very dry seasons. As this paper has to deal with greenhouse control, only those plants found most often infested in, and in the vicinity of, greenhouses will be enumerated.

The greenhouse vegetables most subject to attack are (1) cucumbers, (2) egg plants and (3) tomatoes.

Cucumbers grown under glass in the market-garden district of Boston are rarely exempt from the attacks of red spiders. These plants are first attacked when only two leaves have unfolded, and injury continues until the death of the plant, which in the majority of cases is due primarily to the removal of chlorophyll from its leaves by the mites. Egg plants, although very susceptible to attack, are not generally grown in the vicinity of Boston. Greenhouse tomatoes appear to be practically immune from red spider injury except when very young. Several times the writer has seen a greenhouse containing approximately 1,500 full-grown cucumber plants, with a row of tomatoes planted at each end of the house. The cucumber plants were rapidly dying from the injuries caused by millions of red spiders, while the tomatoes remained unaffected. This was an extremely severe infestation, and shows to what extent greenhouse tomatoes are immune. Almost all weeds found in infested greenhouses harbor mites, and if not destroyed are liable to infect a following crop.

The greenhouse flowers subject to attack are (1) roses, (2) violets, (3) sweet peas, (4) carnations, (5) chrysanthemums and (6) many others of minor importance.

In floriculture perhaps the most important infestations occur on roses and violets, with sweet peas, carnations and chrysanthemums next in order. Usually a very large number of widely differing plants are grown in a florist's greenhouse, and many of these will become more or less seriously infested by the migration of mites from one or more of the above-mentioned plants. However, these infestations are usually not of great importance.

The plants in the vicinity of greenhouses subject to attack are (1) beans, (2) egg plants, (3) celery, (4) tomatoes, (5) strawberries, (6) clover, (7) grasses and (8) weeds.

Plants subject to attack which are found near greenhouses may serve as sources of inside infestation, or may in turn become infested from plants or parts of plants thrown out of the greenhouse during or after an infestation. The most important garden crops attacked are the bean, egg plant and celery. Tomatoes grown out of doors are more susceptible to red spider injury than when grown in greenhouses. Strawberry plants are also subject to attack, but usually this does not assume great importance under New England climatic conditions. The most important plants, as far as the greenhouse man is concerned, are those found around most greenhouses, consisting of clover, grasses and weeds, as these are undoubtedly important factors in causing inside infestation.

NATURE OF INJURY TO CUCUMBERS.

The first signs of injury appear soon after the plants have been transplanted in the greenhouse, and in the majority of cases on the oldest, basal leaves. The pests usually attack the leaves of a cucumber plant progressively; that is, the older, basal leaves first show injury, then those just above are attacked, and thus the ravages of the pest progress upward as the plant grows. As a general rule very young, hairy leaves around the terminal shoot are exempt from attack until the plant becomes very heavily infested.

The injury is caused by the puncturing of the under surface of the leaf and the extraction of the liquid contents of the leaf cells immediately surrounding the puncture, which results in a very characteristic and noticeable injury. In the process of feeding, the green chlorophyll is withdrawn, leaving a small dead area which soon appears on the upper surface of the leaf as a small whitish speck. As the mites continue feeding, the removal of chlorophyll and specking increases until ultimately the leaf becomes yellowish, lifeless and useless for food assimilation.

The characteristic red spider injury is quite easily recognized, even in its early stages of development. The normal leaf is opaque, allowing no light to pass through it, while around injured areas considerable light passes through the leaf tissue, due to the lack of chlorophyll in this vicinity. The contrast between the opaque normal leaf tissue and the lightness seen around affected areas is especially noticeable when the cucumber plants have become full-grown and have leaves and terminal shoots running over the top wires, for at this time the leaves are between the source of light and the observer walking beneath them. The appearance on the upper surface of the minute, pitted dead specks or spots, usually arranged in clusters, will also point to infested areas.

ECONOMIC IMPORTANCE OF THE PEST ON CUCUMBERS.

The damage caused by red spiders in cucumber houses varies in severity. The factors influencing this have not been determined, but at least they are very complicated. The severest injury seems to occur in houses containing a light sandy soil, while houses having heavy soils are better able to withstand the attacks of this pest. Nearly every cucumber grower in the Boston district, so far as the writer has been able to determine, is forced to fight red spiders in order to bring his crop to maturity. In many cases whole houses of young cucumber plants have been destroyed with sulfur fumes because the mites were so numerous and the injuries so severe that it was deemed wise by the grower to destroy the plants and reset the house. The usual methods used by greenhouse men to combat this pest consist of severe pruning of infested plants and spraying with as strong a stream of water as these delicate plants will stand, repeating this as often as possible without allowing mildew to seriously injure the leaves. In nearly all cases the mites win out in the struggle for existence, and shorten the life of a cucumber plant over one month. Under normal conditions the plant should bear a large amount of fruit during this time. The loss, therefore, to cucumber men by red spider infestation is due to shortening the life of the plant during its productive period.

A conservative estimate of the value of the cucumber crop grown within the market-garden district of Boston is $1,500,000 per season. The cucumber growers suffer a loss of approximately $150,000, or 10 per cent. of the whole crop, from the ravages of the red spider alone. Many individual growers have estimated their loss between $2,000 and $5,000 annually.

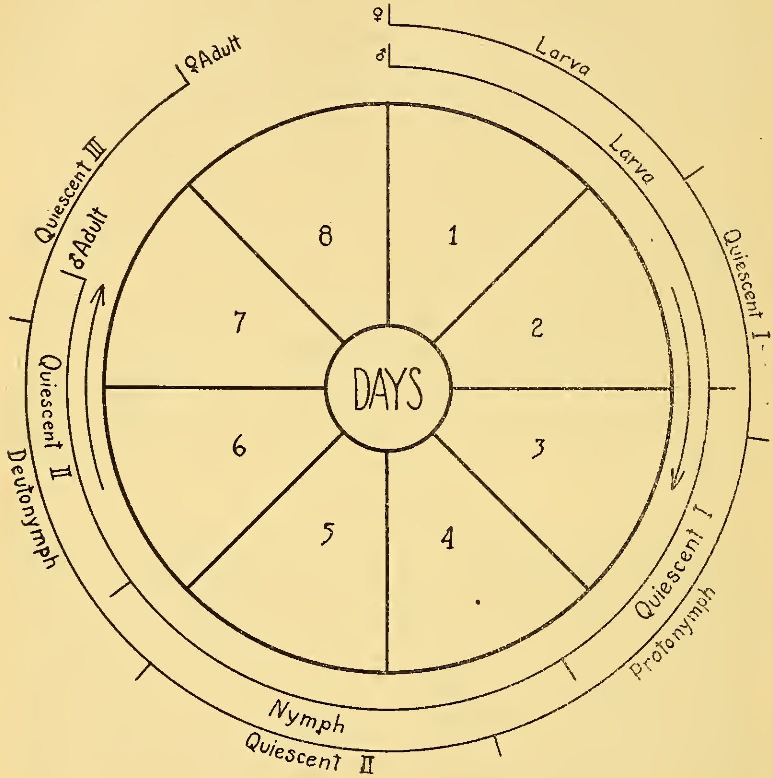
LIFE HISTORY.

An examination of infested cucumbers will reveal the presence of tiny transparent eggs, resembling minute dewdrops, attached to the under surface of a leaf or interwoven among the silvery threads which the mites are capable of spinning. In developing from the egg to the adult stage the red spider follows one of two distinct courses, depending on the sex.

With the female the egg hatches in about four or five days to a tiny colorless, six-legged form known as the larva, which feeds actively for a little over one day. At the end of this time the larva becomes firmly attached to the leaf and enters a quiescent premolting period which lasts for one day. At the termination of this time the skin is shed and there appears an eight-legged form called the primary nymph or protonymph, which feeds for approximately one day and then enters a quiescent premolting period. The duration of this period is approximately the same as that of the larval quiescent stage. From this premolting period there emerges the secondary nymph or deutonymph, which is probably the most voracious of the immature mites. The deutonymphal stage is divided into an active feeding period and a quiescent period, each of which requires one day for its completion, after which the adult female emerges from the deutonymphal molt. For the development from egg to adult it takes seven to eight days under favorable conditions of temperature. (See table on page 159.) The stages of the female red spider and their duration may be represented as follows: —

Egg.	Larva.	Quiescent I.	Protonymph.	Quiescent II.	Deutonymph.	Quiescent III.	Adult ♀.
4–5 days.	1¼ days.	1 day.	1½ days.	1¼ days.	1½ days.	1 day.	15–20 days.

Immediately following the deutonymphal molt the full-grown female establishes herself upon a cucumber leaf and feeds for about two or three days before oviposition takes place. During this short period it mates and shows a tendency to migrate. Following this period for about eight to ten days it deposits about six eggs per day, thus making a total of fifty to sixty eggs laid by a single female. The average duration of life of the adult female in summer is about two weeks, but this period increases as the weather becomes colder.



The development of the male is very similar to that of the female, with the exception that the second nymphal stage is lacking. The other stages, however, require a little longer period for development, so that the time from the egg to the adult is only one day shorter than the development of the female. The different stages of development and the length of each stage of the male red spider may be represented as follows: —

Egg.	Larva.	Quiescent I.	Nymph.	Quiescent II.	Adult ♂.
4–5 days.	2 days.	1¼ days.	2 days.	1¼ days.	5–7 days.

Development of Female Mite from Egg to Adult.

DATE.	1.	2.	3.	4.
1916.				
May 21, A.M.,	–	–	–	–
P.M.,	Hatched.	Hatched.	Hatched.	–
May 22, A.M.,	Larva.	Larva.	Larva.	Hatched.
P.M.,	Larva.	Larva.	Larva.	Larva.
May 23, A.M.,	Quiescent I.	Larva.	Quiescent I.	Larva.
P.M.,	Quiescent I.	Quiescent I.	Quiescent I.	Quiescent I.
May 24, A.M.,	Molted.	Quiescent I.	Molted.	Quiescent I.
P.M.,	Protonymph.	Molted.	Protonymph.	Molted.
May 25, A.M.,	Protonymph.	Protonymph.	Protonymph.	Protonymph.
P.M.,	Quiescent II.	Protonymph.	Quiescent II.	Protonymph.
May 26, A.M.,	Quiescent II.	Quiescent II.	Molted.	Quiescent II.
P.M.,	Molted.	Molted.	Deutonymph.	Quiescent II.
May 27, A.M.,	Deutonymph.	Deutonymph.	Deutonymph.	Molted.
P.M.,	Quiescent III.	Deutonymph.	Quiescent III.	Deutonymph.
May 28, A.M.,	Quiescent III.	Quiescent III.	Quiescent III.	Quiescent III.
P.M.,	Molted (adult ♀).	Quiescent III.	Molted (adult ♀).	Quiescent III.
May 29, A.M.,	–	Molted (adult ♀).	–	Molted (adult ♀).
P.M.,	–	–	–	–

FEEDING HABITS AND DISPERSION.

A mite which has become full-grown, on finding a suitable spot on the under surface of the leaf, settles down to feed, and the results soon become apparent on the upper surface. At first this injury shows as a few small dead or corky specks, but as feeding continues these few are added to until we find a small area literally made up of them. The mite also immediately begins to lay eggs, which soon hatch into young mites. These, however, usually remain feeding in the immediate vicinity of their birth, thus causing more or less concentrated injury at different points on the leaf where older mites have established themselves, forming what might be termed different colonies. As these colonies increase in number the feeding areas also increase, until finally they coalesce and cover practically the whole leaf. This is now absolutely useless to the plant and worthless as a food supply for the large number of mites which inhabit it, and they therefore migrate to other leaves. This migration may be up the plant or may extend to the next plant, provided their leaves are in contact. This new plant may have hitherto escaped injury so that the basal leaves remain uninjured, while an infestation occurs part way up the plant. In natural dispersion the migration is nearly always by full-grown females previous to the egg-laying period. In the majority of cases dispersion within a greenhouse is accomplished wholly by natural agencies.

In artificial dispersion the most important factors are the men engaged in pruning, picking or "rolling up" cucumber plants. They pass from an infested to a non-infested plant, but carry over infestation on their clothing, hands or tools. This means of dispersion becomes exceedingly important when the plants have become so badly infested that webs have been spun over the leaves, as the pickers passing from one house to another carry infestation with them.

NATURAL ENEMIES.

Red spiders out of doors have a very large number of enemies belonging to widely different groups, nine groups of predacious forms embracing thirty-one species having been listed (McGregor, 1917) as attacking the red spider. Under greenhouse conditions, however, red spiders are exceptionally free from enemies. It appears that the red spider enemies are unable to develop in the high temperatures which are necessary for most greenhouse crops. In cucumber houses the writer has repeatedly examined infested leaves in the hope that some enemy would be found able to withstand greenhouse conditions and prove useful in the control of this mite, but these examinations have proved fruitless. On violets which are grown in a humid atmosphere and at a low temperature, a few predaceous mites belonging to the order *Acarina*, family *Gamasidæ*, are very beneficial.

INTRODUCTION TO EXPERIMENTS.

Before taking up the experiments conducted on the artificial control of red spiders a few facts will be summarized in order that the failure of some fumigants and sprays may be better understood.

Cucumber plants grown out of doors are very delicate and susceptible to injury of many kinds, while those grown in forcing houses are much more so. Therefore the sprays and fumigants which can be used with safety to the foliage are very few, while the red spiders are exceptionally hard pests to combat. These two opposing factors have been found extremely hard to satisfy.

Many greenhouse men ask the following question, "Why is fumigation not effective in controlling red spiders?" It has been known for many years that these mites are very resistant to fumigation with our ordinary poisonous gases, such as tobacco and hydrocyanic acid gas. To explain this peculiarity we must contrast the respiratory systems, through which all poisonous gases act, of mites and insects. The latter are efficiently controlled, while only a very few of the former succumb to such treatment.

In insects the respiratory system is composed of several large main air tubes which repeatedly divide, forming very small tubes which ramify into all parts of the body. This system of tracheal tubes opens to the exterior by several small segmentally arranged openings called spiracles, and through these the poisonous gas enters the air tubes, which conduct it to every tissue in the body, and produces sudden death.

Although the tracheal system of the red spider is better developed than in most mites, it is far simpler than in the majority of insects, containing a much smaller number of tubes.

The number and location of the spiracles in red spiders have not been determined because of their minuteness, but they are probably two in number and are situated in the vicinity of the head region. Therefore, although the red spider can be killed by fumigation with hydrocyanic acid gas, it is impossible to do so without severely damaging plant life, due to the concentration of the poisonous gas required.

An infested plant has at all times every developmental stage of the red spider on its leaves, but in artificial control methods we need to consider only three general stages.

1. *Egg Stage.* — At the present time no spray is known which will affect this stage without severely injuring the plant.

2. *Quiescent Stage.* — As explained under the life history, the young larvæ on hatching feed for a day, and then settle down on the leaf in a premolting or quiescent state during which time no nourishment is taken. These quiescent mites form a new chitinous layer beneath the old external skin covering of the preceding stage. Thus during this period a red spider has two chitinous layers covering the body instead of the normal one, and because of this it has been found very difficult to kill by contact sprays. By reference to the life history it will be seen that each female mite passes through three of these quiescent periods before reaching the adult state. If red spiders in this stage of development are not killed by the spray material recommended for control, it will be almost impossible to eradicate this pest unless sprayings are conducted daily.

As soon as the spray applied to an infested plant has evaporated, the mites will be found inactive, and many workers have concluded that all mites above the egg stage have been killed. However, if the leaves were kept under careful observation it would be seen that many of the mites quiescent at the time of application later molt and establish themselves. This point has been overlooked by former workers on the control of red spiders, but is a very important one.

3. *Feeding Stages.* — A large number of spray materials efficiently control mites in the active feeding stages, but because of their inefficient control of the quiescent stages have been discarded.

EXPERIMENTS CONDUCTED IN THE LABORATORY.

Fumigation Experiments.

Several fumigation experiments were conducted in the hope that some gas might be found effective for red spiders without being injurious to cucumber plants.

(*a*) *Sulfur Dioxide* (SO_2).

In many commercial forcing houses sulfur is burned between crops, in order to rid the house of all insects, fungous diseases and mites. To prove whether this was an efficient method, the following experiments were performed.

Powdered sulfur was burned at the rate of one-quarter of a pound per 1,000 cubic feet of space in a tight fumigating box containing a badly infested plant. After twelve hours' fumigation the plant was removed.

Results. — The cucumber plant was severely injured and died. All mites were killed, those quiescent failed to molt and the eggs did not hatch. This experiment was repeated several times and the results checked with those above.

Fumigation with sulfur dioxide is an inexpensive and efficient method of ridding an infested house of mites *between crops.*

Painting Sulfur on Steam Pipes. — This is an old practice of florists in combating the red spider, but has been proved beyond a doubt to be absolutely worthless.

(*b*) *Hydrogen Sulfid* (H_2S).

Potassium sulfid (liver of sulfur) dissolved in water has been widely recommended as an efficient spray for controlling red spiders, and it is claimed that its efficiency depends upon the fact that it combines with the carbon dioxide of the air, forming potassium carbonate and hydrogen sulfid according to the following formulæ: —

Monosulfid: $K_2S + H_2O + CO_2 = K_2CO_3 + H_2S$.

Polysulfid: $K_2S_5 + H_2O + CO_2 = K_2CO_3 + H_2S + 4S$.

As an insecticide it is claimed that this sulfid acts by virtue of its caustic properties and the hydrogen sulfid given off by its decomposition, this gas being for insects almost as poisonous as hydrocyanic acid gas.

To determine whether hydrogen sulfid could be used with safety to plants and still be effective in killing red spiders the following experiment was performed: a plant infested with mites was placed for twelve hours in a fumigating box containing a 1 per cent. atmosphere of hydrogen sulfid.

Results. — The plant was severely injured and died, while the mites and eggs were unaffected.

(*c*) *Carbon Bisulfid* (CS_2).

Experiments using carbon bisulfid at the rate of 2 pounds per 1,000 cubic feet proved to be inefficient in controlling the mites even after a twelve-hour fumigation. The plants in this case were not injured. Carbon bisulfid at a higher rate would be too expensive to use in commercial houses, and therefore further experiments were discontinued.

(*d*) *Benzene or Benzol* (C_6H_6).

Early in the experiments on the control of red spiders it was found that benzene vapor had a very active effect upon the mites. However, this proved to be only a temporary stupefication, and mites which had been removed from the fumigating box containing benzene vapor soon recovered in fresh air. The expense and danger accompanying the use of benzene precludes its use on a commercial scale.

Nitrobenzene and para-dichlorobenzene were experimentally used as fumigants, but proved to be as unsatisfactory as benzene, while nitrobenzene severely injured foliage.

Spraying Experiments.

At present the only known method of controlling red spiders is by the use of sprays. The majority of these act as adhesive sprays, while only a few are truly contact poisons.

(*a*) *Water.*

Water alone has been found very useful in the control of this pest on certain plants, such as the carnation, violet and rose. The usefulness of a water spray lies in the fact that frequent syringing dislodges many mites from the leaves. The majority of these fall to the moist ground and become permanently pasted into the mud. Frequent use of water also prevents the formation of webs, which are quite necessary as a means of travel and dispersal when a leaf becomes thickly populated. Although water is very useful in controlling these mites on certain plants, others cannot be grown in a humid atmosphere without being seriously attacked by fungous diseases, and this is especially true of cucumber plants. The tenderness of the forcing house cucumber also limits the usefulness of a strong stream of water.

(*b*) *Adhesive Sprays.*

1. *Flour Paste.* — Perhaps the most widely known and thoroughly tried adhesive spray is flour paste, recommended by W. B. Parker (1913) in controlling mites attacking hops in the Sacramento Valley, Cal. He found that flour paste made according to the following formula proved to effectively control 99 to 100 per cent. of the mites: 8 pounds of flour boiled in 8 gallons of water to form a paste, and diluted to make 100 gallons of spray.[1]

In order to obtain an accurate estimate of the effectiveness of this spray when used on cucumbers the following experiment was performed: a stock solution of flour paste was made and diluted according to Parker's formula. This spray was applied thoroughly to an infested plant.

Results. — The spray has excellent spreading qualities, and as an adhesive is quite efficient in controlling all mites which at the time of spraying are actively feeding. However, this spray does not affect either the hatching of the eggs or the emergence of the mites from the quiescent stages.

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[1] In a recent government bulletin McGregor and McDonough recommend the use of laundry starch, thus simplifying the process of cooking in forming the stock paste solution.

2. *Soap.* — The addition of soap to a spray material increases its spreading qualities and at the same time adds to its adhesive properties. For red spider control soap is inefficient as a contact poison, but if used in fairly concentrated solutions it proves to be an excellent adhesive spray.

Ivory soap used at the rate of 1½ pounds in 25 gallons of water was tried as a spray and found to be as effective as flour paste (8–8–100), with the advantage of being much easier to make and not requiring constant agitation.

Results. — After this spray has been applied the water evaporates, leaving a brittle film of soap over the mites, which is fairly efficient in sticking these pests to the leaves. However, nearly all mites which are in the quiescent stage molt and establish themselves, and quite a few of the actively feeding mites are able to break the brittle film of soap covering their bodies and thus become liberated to feed on the leaf as before. The eggs are not affected.

A common brand of fish oil soap, at the rate of 1 pound in 10 gallons of water, was applied to mites on cucumbers. The efficiency of this over ordinary soap proved to be very little, if any.

(*c*) *Sulfur and Compounds of Sulfur.*

Sulfur and many of its compounds have been recommended for the control of red spiders attacking various plants. The following have been tried thoroughly, but have proved, for the most part, inefficient.

1. *Dry Sulfur.* — In southern California, where the temperature is high, dusting plants early in the morning so that the dew on foliage will cause the particles of sulfur to adhere has been found very successful, especially upon low-growing plants. The use of resublimed or flowers of sulfur on plants which are not prostrate has proved very unsatisfactory as a control for red spiders. Many of the market gardeners of Boston have thoroughly tried out this method without any material success. Several experiments were conducted, but dusting did not seem to affect the red spiders in the least, even though the temperature was high.

2. *Sulfur as a Liquid Spray.* — This spray has been recommended for controlling red spiders, but experimentally proves to be of very little value.

3. *Sulfur Compounds.* (*a*) *Potassium Sulfid* (*Liver of Sulfur*) K_2S. — This spray has been recommended by McGregor as being very effective in controlling red spiders attacking cotton. Using 3 pounds of potassium sulfid to 100 gallons of water, McGregor found that 100 per cent. of the mites on cotton were killed by this spray. This is an easily prepared material which may be applied with safety to foliage, but at the present time, on account of the increasing demand for potassium salts for use in the manufacture of munitions and fertilizers, this is very difficult to

obtain, while the price is rather high. In using this material on cucumbers it is necessary to add soap to the solution in order to increase its spreading qualities.

Results. — This spray proved to be efficient in controlling actively feeding mites, but only a few of those quiescent failed to molt. The eggs were not affected.

(*b*) *Calcium Sulfid* (CaS_2). — This spray proved to be of little value as it killed but few mites. Soap cannot be added to this solution as it forms an insoluble calcium soap which is precipitated. Had this material proved of value it could be obtained more cheaply in lime-sulfur, of which it is a constituent, than in the form of the pure white calcium sulfid.

(*c*) *Sodium Sulfid* (Na_2S). — To determine whether a substitute for potassium sulfid could be obtained by the use of sodium sulfid, a spray was made by the following formula: —

	Pounds.
Commercial NaOH,	2½
Flowers of sulfur,	5

After solution is complete add water to make 100 gallons of spray.

Results. — Although this spray proved to be as effective in killing all actively feeding mites as did the potassium sulfid solution, its effect on the quiescent stages was materially less. The eggs were not injured.

(*d*) *Soluble Sulfur.* — This is a commercial compound made up principally of sodium sulfid, and as a spray the results check with those given above, with the exception that this spray is very apt to injure the foliage.

(*e*) *Barium Sulfur* (B. T. S.). — This material, used at the rate of 3 pounds to 50 gallons of water, is not injurious to foliage, but is inefficient in controlling mites. Soap cannot be added, as it forms an insoluble barium soap.

(*f*) *Lime-sulfur and Nico-fume Liquid.* — This has been recommended as a spray for spider mites as well as the clover mite (*Bryobia*), and has the following composition: —

Lime-sulfur, commercial (quarts),	2
Nico-fume (pint),	½
Water (gallons),	25

Results. — The application of this material caused considerable injury to the cucumber foliage, while it was only fairly efficient in controlling the mites. Several greenhouse men have sprayed with dilute lime-sulfur solution, but have found it both inefficient in controlling these pests and injurious to the foliage. Nicotine sprays are also inefficient when used alone.

(*d*) *Oil Sprays.*

1. *Sprays containing Petroleum Oils.* (*a*) *Arlington Oil.* — This is a chemically miscible oil containing approximately 90 per cent. petroleum oil. Used at the rate of 1 part oil in 50 parts of water it was found effective

in controlling aphids and thrips, but killed only 50 per cent. of the actively feeding mites. At the above strength this spray severely injured cucumber foliage, and even when diluted to 1 part oil in 100 parts of water, injury still occurred.

(*b*) *Arlington Oil and Black–Leaf–40.* — Formula: oil, 1 part to 125 parts of water; Black–Leaf–40, 1 part to 2,000 parts of water. This combination spray is much more active than the ingredients used separately, but is injurious to the cucumber foliage.

(*c*) *Kerosene Emulsion.* — This is recommended as being efficient in controlling red spiders, but it severely injures tender foliage.

2. *Sprays containing Vegetable Oils.* (*a*) *Lemon Oil.* — This is manufactured by the Lemon Oil Company, Baltimore, Md., and is at present sold at $1.75 per gallon in 5-gallon lots. It is a completely saponified oil soap, and is guaranteed to contain the following ingredients: —

	Per Cent.
Soap,	6
Vegetable oil,	3½
Potassium carbonate,	½
Terabenthine (Turpentine?),	5
Water (not over),	85

Of the many commercial insecticides used experimentally in the control of red spiders this proved the most satisfactory.

Results. — Used at the strength of 1 part lemon oil in 20 parts of water, or 1 pint in 2½ gallons of water, it killed all actively feeding mites, as well as those in the quiescent stage, without injuring the foliage. The eggs are not materially affected by this spray. If young potted cucumber plants are dipped in the above mixture some injury will result to the terminal growing point, but if the plants are sprayed this injury does not occur.

During the spring and summer months of 1916 this spray was thoroughly tried out on a commercial scale, and proved to be very satisfactory, but its expensiveness precludes its free use as a general spray for red spiders.

(*b*) *Experiments on the Duplication of Lemon Oil.* — With the coöperation of Dr. E. B. Holland of the Massachusetts Agricultural Experiment Station a number of spray materials were made in order to determine the killing agent in lemon oil, and for the purpose of duplicating the efficiency of this oil by a substitute which would be less expensive. The following table will briefly show the composition of these mixtures and their relative effectiveness in controlling red spiders: —

	Mixture.										
	Lemon Oil.	1.	2.	3.	4.	5.	6.	7.	8.	9A.	9B.
Soap: —											
B. T. Babbitt's (per cent.),	–	–	–	–	6.00	–	4.50	–	–	–	–
Powdered soap (per cent.),	–	–	–	2.50	–	–	–	–	–	–	–
Soap unknown (per cent.),	6.00	–	–	–	–	–	–	–	–	–	–
Borax soap (per cent.),	–	6.00	–	–	–	–	–	–	–	–	–
Other materials: —											
Sodium hydrate (per cent.),	–	–	1.75	2.00	1.00	1.25	.50	1.66	3.00	3.00	3.00
Rosin (per cent.),	–	–	1.50	2.00	–	–	–	–	2.00	2.00	2.00
Potassium carbonate (K_2CO_3) (per cent.),	.50	–	–	–	–	–	–	–	–	–	–
Oils: —											
Citral (per cent.),	–	4.00	–	–	–	–	–	–	–	–	–
Lemon grass oil (per cent.),	–	–	1.75	3.50	3.50	–	–	–	–	–	–
Linseed oil (per cent.),	–	–	–	–	–	4.00	–	5.00	10.00	10.00	10.00
Turpentine (per cent.),	5.00	5.00	2.50	5.00	5.00	2.50	5.00	–	5.00	5.00	5.00
Unknown vegetable oil (per cent.),	3.50	–	–	–	–	–	–	–	–	–	–
Water (per cent.),	85.00	85.00	92.50	85.00	84.50	92.25	90.00	93.34	80.00	80.00	80.00
Dilution,	1–20	1–10	1–5	1–10	1–10	1–5	1–5	1–1½	1–15	1–15	1–8
Efficiency,	[1]	[2]	[2]	[2]	[2]	[2]	[2]	[1]	[1]	[2]	[3]

[1] Efficient. [2] Not efficient. [3] Fairly efficient.

(*c*) *Linseed Oil Emulsion.* — Thus, out of nine mixtures, only those containing linseed oil proved at all promising. Mixtures 7 and 8 were rather poorly saponified (chemically), while 9*a* and 9*b* were completely saponified; but 7 and 8 proved efficient, while 9*a* and 9*b* were not. This could only be explained by the fact that the free linseed oil was really the toxic agent, and when it was only partly saponified there remained some free linseed oil which established the efficiency of the spray. Upon this supposition were based other preparations containing linseed oil mechanically emulsified in a solution of soap in water. These emulsions proved to be efficient when a 1 per cent. oil spray was used.

Two types of linseed oil emulsion may be made, depending upon the length of time these emulsions are to be retained before use.

Experimentally it was found that the most stable stock emulsion could be made as follows: one-eighth of a pound of Ivory soap (one-half a 5-cent cake) dissolved in a pint of very hot water. After the soap is completely in solution add 1 pint of cold water followed by the addition of 1 pint of raw linseed oil. The oil should be completely emulsified by the use of a bucket pump. This solution is stable, provided the water contained in it is not allowed to evaporate. In using this stock emulsion, especially after it has been kept for some time, it is best to mix one part of stock with an equal volume of water before diluting to desired strength. One part of stock emulsion in 20 parts of water proved to be efficient in killing mites, both in the quiescent and feeding stages.

If spraying is to be done soon after mixing the emulsion it is best to increase the amount of water and soap, and make the emulsion as follows: shave 6 ounces of Ivory soap (1½ 5-cent bars) into 1 gallon of hot water. Add 2 quarts of cold water to cool the solution, then add 1 quart of raw linseed oil and emulsify with a bucket pump. This emulsion, used at the rate of 1 part in 9 parts of water, is very efficient, killing quiescent and feeding mites without injury to leaf tissue.

Soy bean oil substituted for linseed oil proves to be efficient, and in some localities could be used to advantage.

Action of Linseed Oil Emulsion upon Mites. — The majority of oils used as insecticides are regarded as contact poisons. These poisonous oils are supposed to enter the body of the insect, either directly through the thin membraneous chitin of the body segments or by entering the spiracles, where they immediately pass through the tracheal lining and produce an active effect upon the internal structures essential to the life of the insect.

In a previous part of this paper it has been shown that the spiracles are very few, — probably two in number, — and that the body of a red spider is covered by a rather thick and continuous coating of chitin. For these reasons sprays which prove effective in killing aphids are of little value when applied to mite-infested plants.

Many of the spray materials which have given partial success in controlling mites have a marked adhesive action, and from this property linseed oil emulsion derives its efficiency. The spray as made (see "Repressive Measures") contains the amount of soap necessary to hold the oil in suspension and give the spray material excellent spreading qualities. Raw linseed oil contains two types of oils, — (1) drying oil and (2) resinous oil. Upon this fact is based its usefulness in paints, as well as its efficiency as a red spider spray.

A leaf thoroughly covered by the spray soon becomes dry, the water evaporating, while the oil and soap become more and more concentrated as this evaporation continues. Finally there is formed a very thin layer of oil and soap which gradually settles down on to the leaf surface, covering all mites which were feeding on the leaf at the time of application. This film gradually envelops the mite, and the volatile parts of the linseed oil are given off, leaving behind a resinous or waxy oil which securely cements the legs of the mite to itself and to the leaf. Thus the mite is helpless, and the waxy residue of the linseed oil remains, sticking the mite until it dies of starvation. Without doubt some of its effectiveness may be due to its being a contact poison, but its most important quality is its adhesiveness.

Summary of Materials found to be Efficient Experimentally.

No fumigant was efficient in killing red spiders without severely damaging cucumber plants.

Sulfur burned to form sulfur dioxid proved to be very effective in killing all stages of mites. Although this gas is deadly to plant life, its application as a fumigant to rid empty houses of all mites is extremely useful.

Many spray mixtures proved to be efficient in controlling actively feeding mites, but did not affect those in the quiescent stages of development. For the control of all stages above the egg stage lemon oil, a commercial product, and linseed oil emulsion proved to be the most satisfactory. Soapy solutions should also receive some attention as among the most readily prepared spray materials, although their efficiency is only temporary and treatment must be repeated often in order to control these mites.

EXPERIMENTS CONDUCTED IN COMMERCIAL GREENHOUSES.

The materials found to be most efficient in the laboratory experiments were applied to cucumber plants in commercial establishments in order to determine the practicability of spraying for the control of these mites before any recommendations were made.

It was found impossible for the writer to be stationed at these greenhouses during the whole spraying period. Therefore the efficiency of these sprays under commercial conditions has been determined largely by the statements of the growers, checked by more or less frequent personal observations.

LEMON OIL.

The first of these commercial experiments commenced during May, 1916, and continued until the middle of June. Lemon oil, 1 part in 20 parts of water, was thoroughly tested in several greenhouses, and in all cases the spray proved very efficient, provided it was thoroughly applied to the infested plants. At the time the first commercial applications were made the plants were nearly full-grown, and the mites were at that time rapidly spreading through the houses. All that could be expected of this spray was to hold the red spiders in check, so that they would not materially damage the whole house before a good crop of cucumbers had been picked. Owing to the scarcity of labor it was found impossible to apply sprays at weekly intervals, and therefore the results were not as satisfactory as they would have been under other conditions. However, these sprayings held the red spiders in check and prolonged the life of the cucumber plants, which would have died early in the season had no treatment been applied.

In several instances young potted cucumber plants were dipped in a 1 to 20 dilution of lemon oil as they were being set in the greenhouse. This proved to be injurious to the succulent leader, although the leaves gave no indication of injury.

LINSEED OIL EMULSION.

During the summer of 1916 experimental work on the determination of the killing property of lemon oil led to the discovery of linseed oil emulsion and its efficiency in controlling mites. This emulsion has received a very thorough trial in commercial greenhouses this season (1917), and proves to be satisfactory in many respects. The ingredients are always at hand, the initial cost is low, being one-fourth that of lemon oil, and the method of preparation is simple.

Experiment No. 1.

Early in the spring of 1917 this spray mixture was thoroughly tested on a commercial scale in greenhouses located in Watertown, Mass. This range is naturally divided into two groups. Group I. contained the oldest cucumber plants and Group II. the youngest. It was decided that applications should be made to the youngest plants, although they were really too old for effective spraying. The cucumber plants became badly infested in the seed-plant house before being set out. Therefore this infestation became serious soon after the plants were transplanted to the greenhouses. Severe pruning was resorted to, but this did not hold the mites in check. For efficient control, these plants should have been thoroughly sprayed at the time they were transplanted.

Group II. consisted of three greenhouses. In greenhouse No. 1 the plants were very heavily infested, and were 5 feet tall at the time of the first application. In No. 2 the plants were $2\frac{1}{2}$ feet tall and generally infested, although not showing any noticeable injury to the plants from the red spider attack. In No. 3 the plants were 4 feet high and rather severely infested. In each of these houses three applications were made at weekly intervals.

The final results of these experiments are as follows: the greenhouses of Group I. were not sprayed, and though the plants were very little older than those in Group II. they died from the red spider injury after being in the range approximately three months. In Group II. the plants were sprayed and produced fruit for over a month longer than the unsprayed plants of Group I. Houses No. 1 and No. 3 contained such large cucumber plants that a thorough application of a spray was found impossible, but the ravages of these mites were checked during the spraying period. Although a complete control was impossible, the productive life of the crop was lengthened approximately one month. In house No. 2, containing the youngest cucumber plants in Group II., the control was much more efficient, primarily because the plants were smaller and a thorough spraying could be given them. However, even these plants were too large to insure a thorough application after the first spraying.

Experiment No. 2.

Further tests of the efficiency of linseed oil emulsion were made in commercial greenhouses at Arlington, Mass. In this establishment all plants were infested in the seed-plant house while still in pots. Soon after they were set in the greenhouses the first spray was applied, and one week later the second application was made. These two applications were made at the proper time, and controlled the mites so effectually that during midsummer some of these houses were yielding good crops, while only a few scattered plants were beginning to show marked red spider injury. At approximately the same time in former years the plants in these houses have been severely infested and dying from the ravages of the red spider. This range of greenhouses consists of twelve large houses, and therefore it is not surprising that the whole establishment could not be thoroughly covered each week.

An excellent demonstration of the efficiency of linseed oil emulsion was made in the seed-plant house. As stated above, when the cucumber plants were still in pots in this house they were noticeably infested by red spiders. The grower, knowing that this house contained many mites, determined that sprayings should be given with special care, in order to eradicate these pests. Soon after the potted plants were set out in the seed-plant house the first application was given, care being taken to cover thoroughly all the leaf surface. One week after this the second thorough spraying was applied. These applications were made so thoroughly that very few if any mites which originally infested the cucumber plants survived, and the plants attained full growth without showing any red spider injury.

Conclusions drawn from Commercial Spraying Experiments.

Sprayings conducted on bright, sunny days with a rather high temperature in the greenhouse resulted in slight injury to the edges of the leaves, but if applications were made on cool, cloudy days this injury did not occur.

For a thoroughly efficient control at least three applications should be given the cucumber plants at weekly intervals, as soon after they have been set out in the greenhouses as possible.

PREVENTION.

The writer has been unable to conduct a thorough test in eliminating red spiders from the whole range by cultural methods, because it was found impossible to procure an establishment which would serve for this purpose. In commercial greenhouses many factors enter into the red spider problem which cannot be solved unless a suitable range is found which will eliminate these confusing factors in order that some definite knowledge may be gained by using preventive measures. However, under greenhouse conditions, it is the writer's firm conviction that the red spiders can be totally exterminated from commercial ranges by clean culture, both within and outside the greenhouse. It is hoped that some experimental work may be conducted on this important control measure in the near future.

CONTROL MEASURES.

The general biology and development of experimental and commercial control measures have already been discussed, but only in a general way. Under this heading the methods used for the prevention and repression of red spiders will be taken up more in detail. Having established the efficiency of the repressive measures, only the preparation and application of spray materials will be considered.

Preventive Measures.

The solution of the red spider control problem in cucumber greenhouses should be accomplished through preventive efforts rather than by repression, if it is to be done most economically. The commercial grower should do everything possible to eliminate these pests, both within and outside his greenhouses.

In the majority of cases cucumber plants are infested either in the plant house or soon after they have been set out in the greenhouse. The origin of this infestation may be weeds which have harbored mites throughout the winter inside the greenhouse, or weeds and grasses immediately surrounding the house at the base of which the mites winter over and migrate into the greenhouse early in the spring. The first is very important when plants are started very early in the season, while the second is of importance only after the warm days of spring have started these outside weeds.

Fumigation of Greenhouses and Equipment with Sulfur Fumes.

Immediately before setting the cucumber plants in a house, and before fumigation is begun, all boards which are to be used either between the cucumber rows or to make "A" trellises should be taken inside the greenhouse. Do not lay the boards on the ground, but stand them against the steam pipes or in some similar manner to allow the poisonous gas free access to all parts. Other equipment which has been in any way connected with a previous infestation and is to be used during the cucumber season should also be placed in the house for fumigation. Do not introduce living plants until after a thorough fumigation and a subsequent airing of the houses, as sulfur fumes are deadly to plant life.

In fumigating, each house should be tightly closed and sulfur used at the rate of one-third of a pound to every 1,000 cubic feet of space. (Increase to one-half pound in case of houses that are not fairly tight.)

Directions for Fumigation. — Weigh the required amount of sulfur and divide it into four equal parts upon pieces of paper. This is about the right number for a 150-foot house. Metal pans with plenty of breadth are perhaps the best containers for the fumigating operation. First cover the bottom of each pan with chips that have been soaked in kerosene, and distribute these containers at various points through the house, placing beside each the sulfur to be used. When all is in readiness set fire to the chips, and when these are burning well drop in the sulfur. Be certain that the sulfur has ignited and then withdraw from the house. Allow the sulfur fumes to act for at least twelve hours before opening the house. This fumigation may be done during the day or at night, according to the convenience of the grower, and if the method is followed out carefully the red spiders will be completely exterminated within the house.

Special attention should be paid to the house in which potted cucumbers are to be grown, and fumigation should be very thorough, for in many cases the seat of infestation occurs here. At the conclusion of the cucumber crop in the late summer the whole house should be fumigated with sulfur before the plants have died, thus preventing the borders from becoming infested from thrown-out cucumber plants, and reducing the number of red spiders which would otherwise winter over and attack the next cucumber crop.

Destroying Outside Sources of Infestation.

The next problem which confronts the grower is to eliminate the possibility of infesting the houses from outside sources. Investigation has shown that many weeds and grasses, often found around greenhouses, serve as breeding places for these pests, and undoubtedly are the source of inside infestation. In the fall red spiders are found in large numbers on these grassy borders, and being capable of wintering over out of doors, it follows that a large percentage of those found in the fall will also be present in the spring, and are quite certain to migrate to the more attractive cucumber plants within the greenhouse.

Methods of Exterminating Grassy Borders.

1. The border for at least 10 feet away from the house should be thoroughly cultivated, preventing the growth of weeds throughout the season.
2. Where cultivation is not practicable, burning the border may be resorted to.
3. If neither of the above methods can be employed, kill all vegetation around the greenhouse by spraying with sodium arsenite used at the rate of 1 pound to 20 gallons of water. It must be remembered, however, that sodium arsenite is a poison, and care should be taken to prevent animals from grazing on treated borders. Repeat as often as necessary.

Elimination of Artificial Dispersion.

As described under "Feeding Habits and Dispersion," the most important factors in artificial dispersion are the men working in the greenhouses. The grower should systematize, as far as it is practicable, all work which must be done in his houses according to the infestation; for example, in two greenhouses, one showing red spider injury, the other apparently free, pruning or "rolling up" of plants should first be done in the house apparently free from infestation, and later in the infested house. Also in picking cucumbers, the young houses — which usually are not as badly infested as older ones — should be picked first, and older, badly infested houses last. Special care should be exercised not to allow the men who have finished picking in a badly infested house to start pruning or "rolling up" a very young house. Baskets used in picking cucumbers should never be used in a younger house as a receptacle for pruned parts of young plants.

The writer realizes that these recommendations are not all applicable under commercial conditions, but every precaution which is practicable should be taken if artificial dispersion and infestation are to be reduced.

REPRESSIVE MEASURES.

During the early stages of infestation it is frequently found advisable to destroy plants which are found to be badly infested. These badly infested plants should be pulled out before the leaves begin to die, so as to prevent dispersion due to lack of food.

If a few leaves, usually near the ground, are badly infested the pruning of these will lessen the numbers of mites materially. In all cases, whether a plant has been pulled or pruned, the red spiders on these leaves should be destroyed by burning. Do not throw them outside of the house, but destroy them immediately, thus eliminating the chance of infesting plants surrounding the greenhouse. Pruning is especially useful when judiciously applied to the young plants in a greenhouse. Such pruning should be supplemented by spraying for a thoroughly efficient control.

Spraying.

If there is any possibility of infestation, spraying should commence soon after the cucumber plants have been set out in the greenhouse. If spraying is done at this time less material will be used, and a very thorough application can be given in a minimum amount of time. In experiments conducted in commercial greenhouses it was found that red spider sprays applied to young cucumber plants gave very satisfactory results, while on older plants these sprays did not prove as efficient. This can be explained by the fact that a good-sized cucumber plant has a large amount of leaf surface which must be thoroughly covered by the contact spray if efficiency is to be expected. This is economically impossible after the plants have become nearly full-grown, because of the length of time and amount of material necessary to accomplish it. Early spraying will control red spiders at a minimum expense of time, labor and materials.

Linseed oil emulsion is especially adapted for use in commercial greenhouses on a rather large scale.

If only a few plants need to be treated, lemon oil, manufactured by the Lemon Oil Company, Baltimore, Md., may be purchased at nearly all stores carrying insecticides. This, diluted at the rate of 1 part in 20 parts of water, gives a very efficient spray, but for commercial spraying this material is too expensive.

Soapy solutions sprayed upon delicate plants on several successive days prove to be useful. In making this solution a high-grade soap (Ivory soap) should be dissolved at the rate of 4 ounces in 3 or 4 gallons of water.

Preparation of Linseed Oil Emulsion.

(*a*) The necessary articles for preparation are as follows: —

1. Bucket pump.
2. Container or mixing tank. This should hold at least 8 or 9 gallons. For this purpose a small washtub is perhaps the most available. Pails may be used, provided the materials are mixed proportionally.
3. Ivory soap.
4. Raw linseed oil.
5. Hot water.

(*b*) The following proportions of materials for 100 gallons of spray are used: —

1. Five gallons of hot water.
2. One and one-half pounds of Ivory soap. (Six 5-cent cakes or three 10-cent cakes.)
3. One gallon of raw linseed oil.

(*c*) Steps in the preparation of stock solution follow: —

1. Put the required amount of hot water in the container.

2. Shave the Ivory soap into this and stir until completely dissolved.

3. If at this time the temperature of the soap solution is too hot for the hand to bear, dilute with 1 gallon of cold water and let it stand until about body temperature or lukewarm. The cooling of this solution is necessary in order to prepare a permanent emulsion; otherwise the oil will come to the surface on standing (see No. 6). It also prevents the chemical and physical killing properties of the linseed oil from being changed by heat.

4. Add slowly, while stirring vigorously, 1 gallon of linseed oil.

5. Completely emulsify by using the bucket pump. Pump the emulsion from the container through the pump and back into the container again, keeping the nozzle below the surface of liquid. Five minutes' vigorous pumping should completely emulsify this solution.

6. Set aside for a few minutes while preparing spray tank in order to see that oil does not come to the surface.

(*d*) The following are directions for the preparation of spray tank and spray: —

1. Fill the 100-gallon spray tank about one-half full of water. If the water used is too cold, upon the addition of the stock solution the soap will solidify into small lumps, thus spoiling the emulsion. This may occur early in the spring, when the water is very cold, but later in the season ordinary tap water may be used without danger of the soap solidifying on the addition of the stock solution.

2. Add stock solution made above. (See (*c*) 1, 2, 3, 4, 5, 6.)

3. Agitate. (If lumping occurs, the addition of a few pails of hot water will remedy this.)

4. Fill the 100-gallon spray tank.

Application of the Spray.

Outfits and Methods of Spraying. — In commercial greenhouse spraying either a barrel pump or power sprayer should be employed, the latter being the more economical, provided it is available and the size of the establishment warrants its use. For spraying a few plants, or in a very small greenhouse, perhaps the most satisfactory outfit consists of a compressed air sprayer.

The length of hose necessary in spraying cucumber houses depends upon the size of the house and the method of growing cucumbers. If the vertical trellis system is used, in most cases it is best to have the hose of sufficient length to reach from the sprayer down the middle aisle and across the opposite end of the house, thus eliminating the necessity of changing the sprayer during the spraying operations. By passing in a zigzag manner across the house and gradually working backward the house may be thoroughly covered in the least amount of time. If cucumbers are grown on the "A" trellis system the man spraying should travel up on one side of the row and back on the other. In either case a boy should be employed to guide the hose, so that it will not injure the plants as it is pulled from one row to the other.

These are the most common methods of spraying, but there are many modifications which the grower can make according to the conditions surrounding his houses and the manner of growing his plants.

An extension rod made from small piping with an elbowed tip or angle nozzle is absolutely necessary for thoroughness in spraying. If cucumber plants are grown on the vertical trellis system the extension rod should be about 2½ feet in length, while if grown on the "A" trellis system the rod should be 4 feet in length, as this will allow the man spraying to reach the basal leaves of the plants readily. It is perhaps more satisfactory to use a 45° angle nozzle, several of which may be purchased (*e.g.*, Friend and Simplex angle nozzles), thus eliminating the necessity of a separate elbow.

Methods of Application. — From the fact that the red spider as a rule passes its entire existence upon the under surface of a single leaf, early in the season, when the plant is only slightly infested, it is plainly necessary in spraying to cover the entire under side of every leaf. Special attention should be paid leaves showing typical red spider injury, especially the lower leaves of the plant, near the ground, as these are usually most severely infested. To facilitate this under-surface spray an extension rod with an elbow tip or angle nozzle is essential.

The pressure necessary in power spraying varies from 50 to 125 pounds, depending upon the type of nozzle. Do not allow the spray to bombard the under surface of the leaf if a coarse nozzle is used. As this linseed oil emulsion is a contact spray, it is necessary that the whole under surface of a leaf should be covered by a film of this material. If the spray is deposited on the leaf in fine droplets which do not run together, this can be remedied by the adjustment of the pressure until they unite to form a film. If a coarse nozzle is used, as the Simplex, a low pressure will be required for film formation, while with a fine nozzle, as the Friend, a higher pressure will be necessary. A preference should be given the fine nozzle and high pressure, as this is less apt to injure the leaves, while it proves very satisfactory in forming the film. The success or failure of the spraying depends upon this film formation and thorough application of the material.

When Applications should be made. — In general greenhouse practice spraying on bright days is and should be the rule, as with sunshine there is less danger that conditions favorable for disease will result. In the application of the linseed oil emulsion, however, spraying conducted on sunny days with a rather high temperature in the greenhouse may result in a slight injury to the edges of the leaf, while if spraying is done on cool, cloudy days no injury is caused by the applications. Therefore, as far as possible, spraying for the red spider should be done on cloudy days when the temperature in the house is not over 80°. The injury on bright days has never been serious, but should be eliminated as far as possible by proper management of greenhouse temperature and the selection of suitable days for spraying.

In order to effectively control red spider infestations, at least three sprayings given at weekly intervals are necessary.

The first spraying should usually be applied one week after the plants have been set in the greenhouse. If the young plants show mite injury before this time the application should be made as soon as possible. Usually young cucumber plants do not appear to be affected early in the season. However, on closer examination it will be found that the majority of these plants harbor a few mites which, if allowed to develop unhindered, will later become so numerous, and the plant so large by the time injury is noticeable, that an efficient control will be found extremely difficult and expensive.

Since this spray does not destroy red spider eggs it is clear that a second application is necessary to kill the individuals which were eggs at the time of the first spraying. This should be applied seven to eight days after the first. If the second spray is not applied at the proper time it will be almost impossible to control these pests, for many mites will have become adult and laid eggs unless the application is made as recommended.

Some mites are sure to escape the first and second sprayings, and therefore a third application must be given in order to kill these mites, which if not controlled will rapidly multiply and severely injure the plants.

As previously mentioned in the discussion of the "Economic Importance of the Pest," the loss to cucumber growers due to red spider infestation consists in shortening the life of the plant during its productive period. It is absolutely essential that these three sprayings be made as directed, otherwise the producing period of the plants will be reduced at least one month.

Under normal conditions the few mites found early in the season reproduce rapidly until finally the plant becomes seriously affected by the injuries caused by their progeny, and usually dies before producing a full crop. If the mites are held in check by weekly applications early in the season the length of the period during which these regular applications are made will later be added to the adult life of the plant. The longer the spraying period the longer the productive life of the cucumber plant.

It is therefore of great financial importance to the grower to see that these sprayings are thoroughly applied at weekly intervals during the early life of the crop.

Cost of Spraying. — The comparative cost of 100 gallons of spray containing lemon oil and linseed oil is as follows: lemon oil, $8.75; linseed oil emulsion, $1.50.

If sprayings are made with a power sprayer it will take a man, with the help of a boy, approximately three hours to spray thoroughly a greenhouse containing 1,600 cucumber plants about 4 feet high. The material used will amount to 100 gallons. Thus the cost of one spraying when the plants are nearly half grown is approximately $3.

Spray materials,	$1 50
Man, three hours,	1 00
Boy, three hours,	50
	$3 00

This is a fair estimate of the cost of the third spraying. The first and second sprayings taken together should cost approximately $3. Thus, for three applications of linseed oil emulsion to 1,600 plants, the investment for labor and materials will be approximately $6. This should be considered insurance on the crop. At the above rate the cost for three applications is less than one-half cent per plant.

The original investment for spray materials and labor will be repaid many times over by prolonging the fruit-bearing period of the plants.

CONTROL OF RED SPIDERS ATTACKING OTHER CROPS.

Perhaps a few words relative to the control of these mites attacking some of the other crops will prove useful, especially to florists. Although the writer has confined most of his attention to the control of this pest on cucumbers, it is reasonable to suppose the same control measures will give as satisfactory results in eliminating this pest on other plants. While this is true, a few factors must be thoroughly understood in order to procure these results.

On small or rather smooth-leaved plants, such as the violet, rose, carnation, sweet pea and bean, the linseed oil emulsion spray as used on cucumbers does not prove as satisfactory. The reason for this is that the greater part of the spray applied to these plants runs off the leaf, and not enough linseed oil is deposited on the mites to render them helpless. To remedy this difficulty the stock linseed oil emulsion should not be diluted as much as recommended for cucumber spraying. In some cases where very delicate plants are to be sprayed the same dilution may be made, but the solution of soap should be stronger.

In spraying cucumbers a 1 per cent. linseed oil mixture is used. On plants such as the violet it is best that the original linseed oil stock solution be diluted only one-half as much, making a 2 per cent. linseed oil mixture and a more concentrated soap solution.

In the majority of cases proper experimentation by the grower will furnish satisfactory evidence for the required dilution for efficiency on his special crop.

During July and August, 1917, the writer had the opportunity of thoroughly testing the efficiency of this 2 per cent. linseed oil emulsion for the control of red spiders attacking violets in the field at Mr. William Sims' greenhouses, Cliftondale, Mass. This field of violets, containing about

100,000 plants, was sprayed, using a power sprayer, three times between July 15 and September 1. The object of this spraying was not to rid the plants of red spiders, although this undoubtedly could have been accomplished, but to keep their numbers so reduced during the dry summer months that they could not seriously injure the new and tender foliage or kill the plants as they had done in previous years.

The results were entirely satisfactory, and the violet plants were kept practically free from these pests. Those plants rather seriously damaged before spraying began regained their dark green foliage, and during the middle of August only a few leaves could be found in the field showing typical red spider injury. Thus the damage caused by red spiders was reduced to a minimum by spraying, while in previous years and under similar conditions they had practically stripped the plants of their foliage.

The difficulty of thoroughly applying a spray to the lower surface of the leaves of a low-growing plant is well recognized, for our modern nozzles are not adapted to this type of spraying. This difficulty, however, may be overcome in violet spraying by the use of a simple spray nozzle consisting of a "Skinner System" plug. This plug is often used in greenhouses, where it is inserted at intervals in the side of a water pipe. Water passes from the pipe through a small hole in the center of the plug, and then strikes a curved lip which transforms the solid stream to a fine, fan-like spray. This plug is placed in the end of an extension rod 5 feet in length, made from one-eighth-inch piping. The rod is then bent until the fan-like spray travels parallel to the surface of the ground. This type of nozzle proved very satisfactory, and could be held close to the plant without injuring the leaves.

SUMMARY.

The common greenhouse red spider (*Tetranychus bimaculatus* Harvey) is very generally distributed throughout the United States, extending from Maine to Florida, and westward to Texas and California, only a few States in the western arid region being exempt from the ravages of this pest.

The red spider is very cosmopolitan in its feeding habits. In market-garden greenhouses the most important vegetable attacked is the cucumber. In floriculture greenhouses the rose, violet, sweet pea, carnation and chrysanthemum are seriously injured. The most important outside plants, as far as the greenhouse man is concerned, are those found around most greenhouses, consisting of clover, grasses and weeds, as these are undoubtedly important factors in causing inside infestation.

It is estimated that the annual loss to cucumber men in the Boston market-garden district, due to red spider injury, amounts approximately to $150,000, or 10 per cent. of the whole crop.

Experimentation on the control of this mite attacking cucumbers gave no fumigant which could be used with safety to the foliage. Sulfur burned to form sulfur dioxide proved to be very effective in killing all stages of mites. Although this gas is deadly to plant life, its application as a fumigant to rid empty greenhouses of red spiders is extremely useful.

Many spray mixtures proved to be efficient in controlling actively feeding mites, but did not affect those in quiescent stages of development. For the control of all stages above the egg stage linseed oil emulsion proved to be the most satisfactory.

The control of the red spider may be accomplished by combining preventive and repressive measures.

Clean culture, or the eradication of weeds and plants which harbor mites during the winter period, either within or outside the greenhouse, is by far the most vital means of prevention in cucumber greenhouses.

Dispersion within the greenhouse may be hindered by destroying plants or parts of plants which harbor the initial infestation.

Applications of linseed oil emulsion at weekly intervals during the early life of the plant prove very effective if made with extreme care. At least three applications must be made for an efficient control.

By checking red spider infestation early in the season the producing period of the plants is lengthened approximately one month.

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BULLETIN No. 180.

DEPARTMENT OF AGRICULTURE.

REPORT OF THE CRANBERRY SUBSTATION FOR 1916.

BY H. J. FRANKLIN.

The investigations were mainly along the lines pursued in 1915. Many storage tests were conducted with the fruit, the description and results of which will be found particularly interesting.

Blueberry Culture.

A quarter of an acre was planted with six distinct strains of specially selected and bred swamp blueberry stock provided by the Bureau of Plant Industry of the United States Department of Agriculture. This was done under the direction of Prof. Frederick V. Coville, for the most part on August 31, about 375 plants being set out. The rows were 8 feet apart, and the plants were set at intervals of 4 feet in the row. Most of these plants made some growth during the fall, and seemed in good condition when winter began. A check row of unselected stock, taken from a neighboring swamp and planted on May 18, grew well during the summer. Many superior wild plants were selected when in fruit and marked for planting in 1917 as an additional check. It is hoped that the selected blueberry may prove a satisfactory substitute for cranberries on bogs where conditions make the growing of the latter fruit unprofitable. The commercial growing of the blueberry may also develop enough to compete with that of the cranberry in the cultivation of swamp soils, and thus provide a new industry for Massachusetts.

Weather Observations.

Weather observations were made as in previous years, thermometer readings and amounts of precipitation being telegraphed daily to the Boston office of the Weather Bureau during the periods of frost danger, and frost conditions being telephoned to growers on cold nights when asked for. The frost damage on the Cape this season was negligible.

Beginning with the second decade in May, wet weather prevailed more or less until about the 1st of August, culminating on July 24 in an all-day rain in which 4.20 inches fell at the station bog in twenty-four hours, this, because of the previous saturation of the ground, causing the streams to rise so much that the bogs located in considerable watersheds were generally flooded in spite of all efforts to keep the water down. It was estimated that over 1,000 acres of bearing bog on the Cape, either in or a little past the blooming period, were entirely submerged in this way.

The wet season provided unusual chances to study the effects of water on the blossoms and small berries. As a rule, the bogs bloomed heavily, and for a time a record-breaking crop was expected, but an unusually large proportion of the blossoms failed to set fruit. This failure took place especially among the under berries, for the crop turned out to be more "on top" than usual. Almost no berries were commonly found in thick clumps of vines where the blossoms had been very abundant, while in thin vines near by there was a fair amount of fruit. These conditions were general, though less so on bogs that either had no winter-flowage or had it taken off early. The wet weather evidently caused this failure of the set, though it is hard to say definitely how it did so. The rain may have prevented a proper fertilization of the flowers either by washing off the pollen or by preventing bees from working actively. Perhaps an unusual prevalence of fungous diseases induced by the excessive moisture blasted the blossoms.

It is the writer's present opinion, based on general observation and experience, that late holding of the winter-flowage so throws the blossoming period out of its normal season that the danger of its meeting unfavorable conditions for the setting of the fruit is usually considerably increased thereby.

That flooding when the berries are small is dangerous was shown by the effects observed on some bogs submerged for not over fifteen hours with the blooming period past and crop fully set. These bogs lost half their berries in spite of the cloudy weather that prevailed when the water was let off and for three days afterward. The largest of the berries injured under these circumstances were somewhat over a quarter of an inch in diameter. Many of the larger berries on some bogs, however, endured submergence two or three days without apparent injury.

FROST PROTECTION.

In the fall of 1915 tests with new tobacco cloth, used in various ways on a bog with much moss under the vines, showed no considerable temperature advantage.

In the spring of 1916 this cloth was tried on a bog that was fairly well sanded and with only a little moss. Green registering thermometers were used in all the tests. Under one thickness of cloth spread on the vines they showed a higher minimum temperature than thermometers not covered, — by 3 degrees in some cases, though the usual difference was less than 2 degrees. Two thicknesses spread on the vines raised the minimum temperature from 3½ to 5 degrees, according to wind conditions, above that over the unprotected bog. One thickness supported on wires about hip high gave a medium advantage as compared with the single and double thicknesses spread on the vines.

In the fall these tests were continued on patches of unpicked vines on the station bog, and a maximum advantage of about 3 degrees with a single thickness and of 6 degrees with a double one was obtained. Moreover, this advantage continued after the vines had been covered with the cloth continuously day and night for nineteen days in a test begun September 25 and ended October 14.

The experience with this cloth justifies the following conclusions: —

(*a*) This protection is not satisfactory on bogs with much moss under the vines because of the reduced radiation on such bogs.

(*b*) Good secondhand cloth is so hard to get that its use is not practicable.

(*c*) One thickness of new cloth is not enough when spread on the vines.

(*d*) The difficulties and expense of wire supports prohibit their use.

(*e*) With two thicknesses spread on the vines, the protection is probably sufficient for most of the Cape bogs, and this seems the best way to use it. It is too bulky to handle easily on large areas, but it may be left on a bog continuously during quite a long cold period without reducing the protection afforded.

(*f*) It is better to protect with water if it can be done at reasonable expense.

Howes[1] berries that had undergone various low temperatures were picked and examined on November 15, as follows: —

1. Of 433 berries that had endured a temperature of 15⅓° F., 375 were entirely sound and 58 were soft. Eighteen of the latter showed unmistakably that they had decayed from fungous disease, leaving only 40, or 9.64 per cent., that could have been softened by frost; and perhaps even this figure should be reduced on account of fungous rot that could not be distinguished.

2. Of 442 berries that had undergone a temperature of 13½° F., 340 were sound and 102 soft. Of the latter, 26 showed that they had rotted because of fungous diseases, this leaving 76, or 18.27 per cent., that might have been frosted.

3. Of 444 berries exposed to a temperature of 9° F., 200 seemed entirely sound, 244 being soft. Twenty of the latter evidently had been softened by diseases, leaving only 224, or 52.83 per cent., that could have been hurt by frost.

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[1] This variety has been called "Late Howe" in previous reports of the cranberry substation. The writer is informed that it was first taken from the wild, and cultivated by the late James P. Howes of East Dennis, Howes being a common family name in that part of Cape Cod. As "Howe" is evidently a corruption, and as "late" is superfluous, all the varieties that have been called "Howe" being late, the name Howes is considered more appropriate and is therefore used in this report.

The temperatures here recorded were taken with Green minimum registering thermometers hung just over the vines bearing the berries. The fruit was well colored when it underwent these temperatures.

Several tests in both 1915 and 1916 showed that the temperature at which freezing begins among ripened Early Black or Howes cranberries is at or slightly above 22° F., no softening resulting from exposure to 23°.

The records of minimum temperatures at the station bog from 1911 to 1916, inclusive, show that no temperature low enough to harm well-colored berries appreciably occurred in any picking season of those six years.

The results of these investigations show that, for bogs in warm or average locations that are flooded by pumping, it is unprofitable in the long run to try to protect well-colored berries from frost, especially if the crop is light.

Fungous Diseases.

These investigations were conducted, as in previous years, in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture, Dr. C. L. Shear and his assistant, Dr. Neil E. Stevens, visiting the Cape several times during the season, the latter spending several weeks at the station, and both giving sustained and aggressive attention to the more technical side of the work during a considerable period in the growing season and throughout the fall and early winter.

Table 1 is the season's record of the principal Bordeaux mixture spraying plots, experiments with which have been described in previous reports. None of these plots were treated this year, but the record is included here to show the effects on the 1916 crop of the spraying done in former years. Plots A, B, C, D and E were all sprayed in 1911, 1912 and 1913. The treatment was continued on plots A, B and D in 1914, but was stopped on C and E. It was further continued on A (entire plot) and on one-half of B and one-half of D in 1915. Plots 15 and "1913" were sprayed in 1913, 1914 and 1915. The whole of plot 15 has been treated with a complete mixture of commercial fertilizers for several years, as was also the middle part of A in 1913 and 1914. All the plots were picked with scoops as heretofore. Where two checks were taken they were laid out on opposite sides of the plot. The entire sections on which D and E are located, being small, were used as checks. The fruit used in the storage tests was stored, without separating, in quart cans with the covers on tight, but not sealed, the berries being taken by hand from different parts of the picking crates, all the crates picked being thus represented in the cans in most cases.

TABLE 1. — *Spraying Plots (Fungous Diseases). — Results of Spraying with Bordeaux Mixture in Previous Years shown by the 1916 Crop.*

PLOTS AND CHECKS.	Whether sprayed in 1915 or not.	Area (Square Rods).	Variety.	Date Picked, 1916.	Quantity of Fruit obtained (Bushels).	Quantity of Fruit per Square Rod (Bushels).	Quantity of Fruit placed in Storage Test (Quarts).	Period of Storage Test.	Percentage of Rotten and Partly Rotten Berries at End of Storage Test.
A (middle part),	Sprayed,	8	Howes,	Oct. 4	6.67	.83	9	Oct. 4 to Nov. 24	30.84
A (side strips),	Sprayed,	8	Howes,	Oct. 4	5.67	.71	7	Oct. 4 to Nov. 24	25.99
A (check 1),	Not sprayed,	4	Howes,	Oct. 4	5.33	1.33	8	Oct. 4 to Nov. 24	21.20
A (check 2),	Not sprayed,	4	Howes,	Oct. 4	4.60	1.15	8	Oct. 4 to Nov. 24	13.72
B (part sprayed in 1915),	Sprayed,	$7\frac{1}{16}$	McFarlin,	Oct. 7	5.67	.80	9	Oct. 7 to Nov. 23	32.55
B (part not sprayed in 1915),	Not sprayed,	$7\frac{1}{16}$	McFarlin,	Oct. 7	7.13	1.01	8	Oct. 7 to Nov. 23	23.55
B (check),	Not sprayed,	$13\frac{2}{3}$	McFarlin,	Oct. 7	12.83	.94	7	Oct. 7 to Nov. 24	23.27
C,	Not sprayed,	16	Howes,	Oct. 4	12.67	.79	8	Oct. 4 to Nov. 27	18.60
C (2 checks),	Not sprayed,	12	Howes,	Oct. 4	11.78	.98	8	Oct. 4 to Nov. 27	19.22
D,	One-half sprayed,	16	Early Black,	Sept. 29	12.83	.80	8	Sept. 29 to Dec. 2	51.68
D (check),	Not sprayed,	$40\frac{3}{10}$	Early Black,	Sept. 29	30.83	.77	8	Sept. 29 to Dec. 2	40.43
E,	Not sprayed,	16	Early Black,	Sept. 29	25.50	1.59	16	Sept. 29 to Dec. 4	44.42
E (check),	Not sprayed,	64	Early Black,	Sept. 29	63.25	.99	16	Sept. 29 to Dec. 4	40.58
"1913,"	Sprayed,	9	Howes,	Oct. 4	8.88	.98	8	Oct. 4 to Nov. 20	28.81
"1913" (check),	Not sprayed,	3	Howes,	Oct. 4	2.20	.73	5	Oct. 4 to Nov. 20	14.11
Sprayed half of fertilizer plot 15,	Sprayed,	4	Early Black,	Sept. 23	1.86	.47	6	Sept. 23 to Dec. 8	64.07
Other half of plot 15,	Not sprayed,	4	Early Black,	Sept. 23	2.67	.67	6	Sept. 23 to Dec. 8	62.12

TABLE 2. — *Spraying Plots (Fungous Diseases). — Results of Spraying with Bordeaux Mixture in Previous Years shown by the 1915 Crop.*

PLOTS AND CHECKS.	Whether sprayed in 1914 or not.	Area (Square Rods).	Variety.	Date picked, 1915.	Quantity of Fruit obtained (Bushels).	Quantity of Fruit per Square Rod (Bushels).	Quantity of Fruit placed in Storage Test (Bushels).[1]	Period of Storage Test.	Percentage of Rotten and Partly Rotten Berries at End of Storage Test.
B (part not sprayed in 1915),	Sprayed,	$7\frac{1}{16}$	McFarlin,	Oct. 13	3.07	.435	3	Oct. 13 to Jan. 7	19.05
B (check),	Not sprayed,	$13\frac{2}{3}$	McFarlin,	Oct. 13	10.83	.793	4	Oct. 13 to Jan. 7	12.60
D (part not sprayed in 1915),	Sprayed,	8	Early Black,	Sept. 22	5.00	.625	4	Sept. 22 to Jan. 5	33.41
D (check),	Not sprayed,	12	Early Black,	Sept. 22	13.75	1.146	4	Sept. 22 to Jan. 5	28.63

[1] Stored in bushel picking crates.

The table shows that as a rule the areas sprayed in 1915 were less productive in 1916 than their untreated checks, and that the fruit from these sprayed areas was inferior in keeping quality in all cases in 1916. In this connection the figures given for plots B and D in Table 2, taken from the last report of the substation (Bulletin No. 168, page 3), are of interest.

Judging by the results of the 1915 and 1916 storage tests given in Tables 1 and 2, the resistance of the plants to the attack of fungous diseases had been weakened by the injury caused by Bordeaux mixture described in previous reports.

Three plots, numbered, respectively, B. L. 1, B. L. 2 and B. L. 3, were sprayed with "Black-Leaf 40" used at the rate of 1 part to 400 parts of water, 2 pounds of resin fish-oil soap to 50 gallons being added to spread and stick the spray, on the dates and with the results shown in Table 3. These plots and their checks were all picked with scoops. The storage-test fruit was stored, without separating, in quart cans with covers on tight but not sealed, the berries being taken by hand from different parts of the picking crates, all the crates being thus represented.

The spray evidently did not much affect the quantity of fruit, and the storage tests showed no fungicidal value for it. This was not entirely a fair test, as all the sprayed areas had been treated with complete commercial fertilizer mixtures in 1915, but the impairment in keeping quality shown by the sprayed berries as compared with the check fruit was in all cases greater than that heretofore found by the writer to have resulted from the use of fertilizers. Did this spray have a harmful effect in this regard in some way?

Two plots, numbered A. L. 1 and A. L. 2, were sprayed with "Corona" arsenate of lead, used at the rate of 3 pounds to 50 gallons of water, on the dates and with the results shown in Table 4. These plots and their checks were picked with scoops, and the storage-test fruit was selected and stored in the same way as that of the "Black-Leaf 40" plots.

TABLE 3. — *Spraying Plots (Fungous Diseases). — Negative Results with "Black-Leaf 40" and Resin Fish-oil Soap.*

PLOTS AND CHECKS.	Variety.	Area (Square Rods).	Date of First Spraying.	Date of Second Spraying.	Date of Third Spraying.	Date Berries were picked.	Quantity of Fruit obtained (Bushels).	Quantity of Fruit Per Square Rod (Bushels).	Quantity of Fruit placed in Storage Test (Quarts).	Period of Storage Test.	Percentage of Rotten and Partly Rotten Berries found at End of Storage Test.
B. L. 1, ...	Early Black, . .	8	June 28	Aug. 1	Aug. 19	Sept. 23	4.00	.50	8	Sept. 23 to Dec. 2	57.17
B. L. 1 (check), . .	Early Black, . .	8	-	-	-	Sept. 23	7.50	.94	8	Sept. 23 to Dec. 2	40.89
B. L. 2, ...	Howes, ...	8	June 28	Aug. 1	Aug. 19	Oct. 5	8.17	1.02	8	Oct. 5 to Nov. 20	26.62
B. L. 2 (check), . .	Howes, ...	6	-	-	-	Oct. 5	6.50	1.08	8	Oct. 5 to Nov. 20	19.69
B. L. 3, ...	Early Black, . .	4	June 28	Aug. 1	Aug. 19	Sept. 26	3.33	.83	6	Sept. 26 to Nov. 27	53.70
B. L. 3 (check), . .	Early Black, . .	4	-	-	-	Sept. 26	3.17	.79	6	Sept. 26 to Nov. 27	38.45

TABLE 4. — *Spraying Plots (Fungous Diseases). — Results with Arsenate of Lead.*

PLOTS AND CHECKS.	Variety.	Area (Square Rods).	Date of First Spraying.	Date of Second Spraying.	Date of Third Spraying.	Date Berries were picked.	Quantity of Fruit obtained (Bushels).	Quantity of Fruit Per Square Rod (Bushels).	Quantity of Fruit placed in Storage Test (Quarts).	Period of Storage Test.	Percentage of Rotten and Partly Rotten Berries found at End of Storage Test.
Plot A. L. 1, . . .	Early Black, . .	9	June 28	Aug. 1	Aug. 19	Sept. 25	11.00	1.22	8	Sept. 25 to Nov. 25	30.04
A. L. 1 (check 1), . .	Early Black, . .	6	-	-	-	Sept. 25	6.67	1.11	8	Sept. 25 to Nov. 25	36.02
A. L. 1 (check 2), . .	Early Black, . .	9	-	-	-	Sept. 25	9.80	1.09	8	Sept. 25 to Nov. 25	33.70
Plot A. L. 2, . . .	Early Black, . .	9	June 28	Aug. 1	Aug. 19	Sept. 21	9.40	1.04	14	Sept. 23 to Nov. 29	35.30
A. L. 2 (check 1), . .	Early Black, . .	6	-	-	-	Sept. 21	6.10	1.02	12	Sept. 23 to Nov. 29	40.92
A. L. 2 (check 2), . .	Early Black, . .	6	-	-	-	Sept. 21	6.00	1.00	12	Sept. 23 to Nov. 29	44.13

The table shows little if any increase in yield from this treatment. The berries of both plots, however, showed a rather remarkable improvement in keeping quality over the fruit of the unsprayed checks, especially when the small number and lateness of the treatments are considered. In both cases the two checks were laid out on opposite sides of the plot.

While these tests are not enough to prove a fungicidal value for arsenate of lead in the treatment of any cranberry disease, their results are suggestive. It should be recalled in this connection that this insecticide is a well-proved treatment for apple scab. Dr. Shear found that most of the rot in Early Black berries produced by the station bog this year was due to anthracnose, a disease caused by a fungus known to science as *Glomerella rufomaculans vaccinii* Shear.

To test further the possibility of controlling fungous diseases by putting copper sulfate in the flowage, experimental flooding sections 23 and 27 of the station bog were treated, as in 1915, with this chemical in the June reflow at the rate of 1 part to 50,000 parts of water (1 pound in 6,250 gallons). The treatment was applied June 14 after the sections had been completely submerged for twelve hours, and the water was then held thirty hours longer. Even distribution of the chemical was obtained by pulling it around in a sack in the water as it dissolved. The areas thus treated showed no definite advantage either in the quantity or the keeping quality of the fruit, as compared with the untreated flooding sections adjoining them.

It seemed to be the general opinion among the Cape growers that cranberries as a rule kept distinctly better than usual this year in spite of the wet weather in the first half of the growing season.

The hypertrophy of the tender vegetative shoots, frequently called "false blossom" by the growers, and for which Dr. Shear has suggested the name "rose bloom," was unusually abundant on the station bog this season. It has been thought that the moisture conditions attending late holding of the winter-flowage, excessive reflowage, deficient drainage or excessive and continual rainfall greatly favor the development of the fungus (*Exobasidium oxycocci* Rostr.) which causes this disease. The late holding of the winter-flowage in both 1915 and 1916 in conjunction with the very rainy season may, therefore, partly explain its prevalence on the bog.

An unusual occurrence with this disease was its attack on the blossoms, its effects hitherto, so far as observed, being confined to the leafy shoots. As estimated from 3 to 4 per cent. of the Howes blossoms on the station bog were conspicuously deformed by the disease between July 20 and August 1, when this effect was most marked. An occasional Early Black flower was also affected. A few of the small berries were somewhat swollen and discolored by the disease, and covered with the spores of the fungus. That this attack on the flowers and small berries probably was due mainly to the prolonged spell of wet weather was shown by the prompt disappearance of the disease on both blossoms and vines when the wet season ended.

Dr. Shear has recently published a valuable paper[1] on the false blossom disease that does so much harm in Wisconsin and has heretofore been reported[2] as having been introduced into Massachusetts and New Jersey.

Storage Tests.

The description of all these experiments that seemed to give results of much interest are arranged in the groups listed below. Those in group No. 1 were planned by the writer and conducted by Prof. F. W. Morse, research chemist of the Massachusetts Agricultural Experiment Station. Group No. 2 was planned and carried out by Dr. N. E. Stevens. Nos. 4, 6 (*c*), 7, 10 and 13 were planned and conducted by the writer. Nos. 3, 5, 6 (*a*) and (*b*), 8 and 11 were planned by Drs. Shear and Stevens, and were carried out by them co-operatively with the writer. No. 12 was planned and conducted co-operatively by Dr. Stevens and the writer.

Some of the tests were conducted with berries in quart cans, with covers on tight but not sealed, and others with fruit in bushel picking crates stored in carefully arranged stacks. A comparison of the percentages of decay found in the crates and the cans shows strikingly the harmful effect of the lack of ventilation in the latter, this being so great that it perhaps invalidates the results of the can tests.

In all the tests, except those of groups 1, 2, 9, 11 and 13, the fruit was examined by cup samples by the screeners employed at the station during the fall, under the writer's supervision, the inspector's cup of the New England Cranberry Sales Company being used for sampling. The Sales Company's hand grader was used to facilitate the work. All the berries stored in cans were included in samples and examined.

The "nine-sample" method was largely used in examining the crates. In this method nine samples from each crate were counted, one being taken from the top or surface berries at each end; one from the surface berries at the middle; one from the berries halfway between the top and bottom at each end; one from the very center; one from the very bottom at each end; and one from the bottom at the middle.

The "seven-sample" method was used in examining some of the crated berries, and the writer thinks this method is as satisfactory as any likely to be devised for determining the condition of berries thus stored, considerable defects in the other methods so far employed having been discovered. In this method seven samples from each crate were examined, one being taken from the surface berries of each half of the crate halfway between the middle and the end; one from each half of the crate halfway between the top and the bottom and halfway between the center and the end; one from the very center; and one from the very bottom of each half of the crate halfway between the middle and end.

All the tests except those of the first, second, eleventh and thirteenth groups were conducted in the basement of the station screenhouse, this having a floor and walls of concrete and providing fairly even temperatures.

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[1] False Blossom of the Cultivated Cranberry, Bul. No. 444, U. S. Dept. Agr., November, 1916.

[2] Bul. No. 160, Mass. Agr. Expt. Sta., 1915, pp. 99 and 100, and Bul. No. 168, Mass. Agr. Expt. Sta., 1916, p. 5.

A Friez hygro-thermograph provided by the Bureau of Plant Industry and kept in the storage room during most of the period when the tests were in progress gave the following temperature and humidity records: —

Between September 29 and October 1 the temperature fell from 77° F. to 60° F. Between October 1 and October 5 it ranged between 61° and 54°. As the mainspring of the hygro-thermograph clock broke on October 5 the records were discontinued until October 25. Beginning on that date the ranges in temperature by weeks were as follows: October 25 to November 1, from 57° to 53°; November 1 to November 8, from 53° to 47°; November 8 to November 15, from 51° to 44°; November 15 to November 22, from 47° to 38°; November 22 to November 29, from 51° to 38°; November 29 to December 6, from 51° to 43°; December 6 to December 13, from 49° to 40°; December 13 to December 20, from 42° to 29°; December 20 to December 24, from 41° to 34°.

Between September 29 and October 5 the relative humidity ranged from 95 to 59 per cent., and was subject to much influence from frequent opening of the storage room. Beginning with October 25 the ranges in relative humidity by weeks were as follows: October 25 to November 1, from 85 to 72 per cent.; November 1 to November 8, from 85 to 69 per cent.; November 8 to November 15, from 85 to 60 per cent.; November 15 to November 22, from 73 to 60 per cent.; November 22 to November 29, from 86 to 53 per cent.; November 29 to December 6, from 75 to 46 per cent.; December 6 to December 13, from 71 to 50 per cent.; December 13 to December 20, from 72 to 53 per cent.; December 20 to December 24, from 79 to 55 per cent.

The storage room was kept tightly closed from October 25 to December 24, except as the making of observations made entrance necessary. In spite of this, the fluctuations in relative humidity were marked and rapid, it evidently being influenced much more by outside weather conditions than by the stored berries.

The storage tests conducted fall conveniently into groups, as follows: —

1. *Weight Shrinkage of Sound Cranberries in Storage is due largely, if not entirely, to Losses Incidental to the Process of Respiration, not to Loss of Water by Evaporation.* — To determine this, Professor Morse weighed and analyzed different lots of Howes berries, obtained from the same source, on various dates and with results as shown in Table 5. Professor Morse provides the following data concerning this work: —

> The cranberries were received at the chemical laboratory the first week in December.
>
> On December 8, eight approximately equal lots of carefully selected sound berries were weighed into glass jars. The mouths of the jars were covered with a thin filter paper held in place by rubber bands, and they were inverted in a slat-bottomed box and placed in a cool closet, the temperature of which ranged between 35° and 60° F.

The berries were put into jars to prevent too free circulation of air, and the jars were inverted to permit the heavy carbon dioxide gas to diffuse through the filter paper and escape. Beginning December 16, and thereafter at fortnightly intervals, a jar was removed from the closet. The contents were weighed, rotten berries were picked out and weighed, and a sample of sound berries was used for an estimation of the actual dry matter in the fruits.

Each successive date showed more and more decayed fruit, and on March 17 the last two jars were removed together, because it seemed useless to continue the experiment further.

TABLE 5. — *Analyses of Cranberries. — Dry-Matter Content at End of Various Periods of Storage.*

LOT.	Weight December 8 (Grams).	Date reweighed and analyzed.	Weight after Keeping (Grams).	Loss (Per Cent.).	Dry Matter in Sound Fruit (Per Cent.).	Weight of Rotten Fruit (Grams).
A, ...	153.4	Dec. 16	152.7	-	12.12	-
B, ...	156.8	Jan. 2	154.9	1.2	12.14	25.4
C, ...	158.1	Jan. 16	154.7	2.1	11.87	44.7
D, ...	158.5	Feb. 2	153.8	2.9	11.94	67.6
E, ...	158.6	Feb. 16	152.8	3.6	11.94	70.0
F, ...	161.3	Mar. 3	154.5	4.2	12.02	85.3
G, ...	161.7	Mar. 17	153.2	5.2	11.82	92.7
H, ...	164.9	Mar. 17	157.0	4.7	-	89.0

Professor Morse remarks concerning these results as follows: —

> The loss in weight is due partly to the shrinkage in the decayed berries, which is caused by decomposition and evaporation.
>
> The sound fruit showed a small but positive diminution in dry matter after the first fortnight, but not an increasing one. Only by weighing individual berries could it be positively determined how much the cranberry loses in weight while yet sound. The small shrinkage in proportion of dry matter indicates that respiratory destruction occurs, as in apples, pears, etc.

2. *Temperature of Berries when picked.* — These investigations were not storage tests, strictly speaking, but as their results bear on the matter of cooling previous to storage they are included here.

Air temperatures and temperatures taken among berries in crates as soon as they were filled by pickers were recorded by Dr. Stevens, as shown in Table 6.

TABLE 6. — *Temperatures of Cranberries when picked compared with Air Temperatures.*

BOG WHERE TEMPERATURES WERE TAKEN.	Date, and Condition of the Weather when the Temperatures were taken.	Variety of Berries.	Hour of Day Temperatures were taken.	Air Temperature in Shade.	Temperature of Berries when picked (taken at Center of Picking Crate).
Station, . . .	Oct. 3, clear and sunny.	Howes, . .	7.30 A.M.	49° F.	49° F.
			8.30 A.M.	60° F.	62° F.
			9.00 A.M.	62° F.	64° F.
			9.20 A.M.	62° F.	68° F.
			9.40 A.M.	63° F.	75° F.
			10.40 A.M.	70° F.	79° F.
			11.00 A.M.	70° F.	79° F.
			11.30 A.M.	71° F.	81° F.
			11.55 A.M.	71° F.	81° F.
			2.15 P.M.	70° F.	75° F.
			2.55 P.M.	70° F.	74° F.
			3.00 P.M.	70° F.	73° F.
Station, . . .	Sept. 20, bright sun.	Early Black, .	11.10 A.M.	66° F.	81° F.
			3.30 P.M.	64° F.	70° F.
			4.30 P.M.	61° F.	65° F.
Station, . . .	Sept. 18, . .	Early Black, .	11.15 A.M.	75° F.	84° F.
			12.45 P.M.	74° F.	85° F.
			1.30 P.M.	74° F.	82° F.
			3.40 P.M.	67° F.	72° F.
Station, . . .	Sept. 23, . .	Early Black, .	9.30 A.M.	75° F.	80° F.
			11.30 A.M.	76° F.	87° F.
			11.45 A.M.	76° F.	89° F.
Old Colony bog, South Dennis, Mass.	Sept. 22, . .	Early Black, .	11.30 A.M.	73° F.	86° F.
			11.45 A.M.	73° F.	89° F.
			3.00 P.M.	73° F.	86° F.

These records show that under ordinary harvesting conditions cranberries attain high temperatures on the vines. It has been found that with the crate containers commonly used these temperatures do not change rapidly unless the berries are placed in very cool storage after they are picked.

The difference between the temperature of the air and that of the berries when picked is greatest when the sun is highest, and is least early in the morning and late in the afternoon. Tests with green and ripe berries in small glass containers failed to show any appreciable difference between berries of different colors.

3. *Hand-picking* v. *Scoop-picking as affecting Keeping Quality.* — Two series of tests come under this head, as follows: —

(*a*) Twelve parallel and adjacent strips of Early Black vines, each approximately 50 feet long by 5½ feet wide, were picked in alternation with scoops and by hand on September 18, a single full crate being obtained from each strip. In the hand-picking, each man was allowed to follow his own method, and a great difference was observed in the ways in which they did the work, some tearing the berries from the vines with their fingers used much like scoop-teeth, and some picking individual berries much as strawberries are commonly gathered. Six of the crates, three hand-picked and three scoop-picked, were placed in the storage room at once, the rest being left in the sun on the bog for several hours. Test No. 1 of Table 7 completes the record of these tests.

(*b*) Twelve crates of Howes berries, picked by hand and with scoops in alternation, as in the first series of tests, from an equal number of narrow parallel and adjacent strips of vines, were handled as indicated in test No. 2, of Table 7.

The averages of the table show that the scooped berries kept slightly better than the hand-picked ones in both series of tests. All this fruit was stored as it came from the bog without cleaning in any way. The crates were examined by the "nine-sample" method in determining the rot percentages.

TABLE 7.—*Hand-picking v. Scoop-picking as affecting Cranberry Keeping, and Effect on Keeping of leaving Berries in the Sun instead of housing them promptly.*

Test No. 1, Early Black Variety.

LOT NO.	Method and Date of picking.	Quantity of Fruit (Bushels).	Housed at once or left on Bog in Sun.	Crate No.	Hour of Day picked.	Temperature of Berries when picked.	Hour of Day housed.	Temperature when housed.	Period of Storage Test.	Percentage of Rotten and Partly Rotten Berries found at End of Storage Test.	Averages of Percentages of Rotten and Partly Rotten Berries.	Averages of Percentages.
A, . . .	By hand, Sept. 18, .	6	Housed at once, .	1	1.45 P.M.	82° F.	2.00 P.M.	82° F.	Sept. 18 to Dec. 14	27.60	25.66	27.05
				2	2.30 P.M.	78° F.	2.45 P.M.	78° F.	Sept. 18 to Dec. 14	29.84		
				3	3.15 P.M.	72° F.	3.30 P.M.	72° F.	Sept. 18 to Dec. 11	19.54		
			Left on bog, .	4	11.15 A.M.	84° F.	4.00 P.M.	81° F.	Sept. 18 to Dec. 14	28.34	28.43	
				5	11.30 A.M.	84° F.	4.00 P.M.	81° F.	Sept. 18 to Dec. 14	28.34		
				6	1.15 P.M.	82° F.	4.00 P.M.	81° F.	Sept. 18 to Dec. 14	28.60		
B, . . .	With scoops, Sept. 18, .	6	Housed at once, .	1	2.00 P.M.	82° F.	2.15 P.M.	82° F.	Sept. 18 to Dec. 14	25.61	23.83	25.98
				2	2.30 P.M.	78° F.	2.45 P.M.	78° F.	Sept. 18 to Dec. 11	22.57		
				3	3.45 P.M.	72° F.	4.00 P.M.	72° F.	Sept. 18 to Dec. 14	23.32		
			Left on bog, .	4	11.10 A.M.	84° F.	4.00 P.M.	81° F.	Sept. 18 to Dec. 14	27.38	28.14	
				5	11.45 A.M.	85° F.	4.00 P.M.	81° F.	Sept. 18 to Dec. 14	28.55		
				6	1.30 P.M.	82° F.	4.00 P.M.	81° F.	Sept. 18 to Dec. 14	28.50		

Test No. 2, Howes Variety.

LOT NO.	Method and Date of picking.	Quantity of Fruit (Bushels).	Housed at once or left on Bog in Sun.	Crate No.	Hour of Day picked.	Temperature of Berries when picked.	Hour of Day housed.	Temperature when housed.	Period of Storage Test.	Percentage of Rotten and Partly Rotten Berries found at End of Storage Test.	Averages of Percentages of Rotten and Partly Rotten Berries.	Averages of Percentages.
C, . . .	By hand, Oct. 3, . .	6	Housed at once, .	1	11.15 A.M.	81° F.	11.30 A.M.	81° F.	Oct. 3 to Dec. 14	14.93	14.99	13.24
				2	11.45 A.M.	81° F.	12.00 M.	81° F.	Oct. 3 to Dec. 14	14.67		
				3	2.35 P.M.	74° F.	3.00 P.M.	74° F.	Oct. 3 to Dec. 14	15.38		
			Left on bog, .	4	10.30 A.M.	79° F.	4.00 P.M.	76° F.	Oct. 3 to Dec. 14	8.21	11.48	
				5	10.45 A.M.	79° F.	4.00 P.M.	76° F.	Oct. 3 to Dec. 14	9.86		
				6	2.00 P.M.	75° F.	4.00 P.M.	75° F.	Oct. 3 to Dec. 14	16.37		
D, . . .	With scoops, Oct. 3, .	6	Housed at once, .	1	11.25 A.M.	81° F.	11.30 A.M.	81° F.	Oct. 3 to Dec. 14	12.06	11.25	10.98
				2	11.55 A.M.	81° F.	12.00 M.	81° F.	Oct. 3 to Dec. 14	12.05		
				3	2.45 P.M.	73° F.	3.00 P.M.	73° F.	Oct. 3 to Dec. 14	9.64		
			Left on bog, .	4	10.35 A.M.	79° F.	4.00 P.M.	76° F.	Oct. 3 to Dec. 14	11.16	10.71	
				5	10.55 A.M.	79° F.	4.00 P.M.	76° F.	Oct. 3 to Dec. 14	10.70		
				6	2.10 P.M.	76° F.	4.00 P.M.	75° F.	Oct. 3 to Dec. 14	10.26		

In partial confirmation of the evidence presented above, that scoop-picking is not especially harmful to the keeping quality of cranberries, a recital of the experience with 14 bushel crates of Early Black berries picked with scoops in two different ways from narrow alternating parallel and adjacent strips of vines is here included. In picking seven of these crates the scoops were allowed to fill to a considerable extent as usual before emptying, the berries churning back and forth as they accumulated. With the other boxes the berries were not allowed to collect as they were picked, but were poured out of the scoops after each pull through the vines. The results of the storage of this fruit are shown in Table 8. The churned berries kept as well as the unchurned. The crates were examined by the "nine-sample" method.

TABLE 8. — *Picking Test. — The Scoop-churning of Berries during the Process of Picking does not materially affect Keeping Quality.*

HOW BERRIES WERE SCOOPED.	Date picked and stored.	Quantity stored (Bushels).	How stored.	Date examined to determine Rot Percentage.	Percentage of Rotten and Partly Rotten Berries found at End of Test.
With churning, .	Oct. 8	7	Unseparated, in picking crates, .	Dec. 19	29.51
Without churning, .	Oct. 8	7	Unseparated, in picking crates, .	Dec. 19	29.64

4. *Relative Keeping Quality of the Upper and Under Berries of the Vines.* — The three tests to determine this were carried out as indicated by Table 9, the results showing rather conclusively that the berries most exposed to sun and wind during their growth are considerably better keepers than those produced under the protection of the vines. Moreover, the top berries were much more highly colored and averaged considerably larger in size than the others when picked.

These berries were all picked by hand under the supervision of the writer, who did much of the work himself. They were stored in quart cans.

TABLE 9. — *Upper and Under Berries compared as to Keeping Quality.*

Test No.	VARIETY.	Berries.	Date picked.	Quantity placed in Storage Test (Quarts).	Period of Storage Test.	Percentage of Rotten and Partly Rotten Berries found at End of Storage Test.
1, .	Early Black, .	Only sound upper berries.	Sept. 30	6	Sept. 30 to Dec. 2	31.55
		Only sound under berries.	Sept. 30	6	Sept. 30 to Dec. 2	38.83
2, .	Early Black, .	Only sound upper berries.	Oct. 6	14	Oct. 6 to Nov. 20	28.74
		Only sound under berries.	Oct. 6	12	Oct. 6 to Nov. 21	37.93
3, .	Howes, . .	Only sound upper berries.	Oct. 13	6	Oct. 13 to Dec. 9	15.49
		Only sound under berries.	Oct. 13	6	Oct. 13 to Dec. 9	18.44

It seems to be the general experience with Cape Cod bogs that late holding of the winter-flowage improves the keeping quality of the berries. As the writer has observed that late holding of the water frequently reduces the quantity of under berries as compared with the amount of fruit produced in the tops of the vines, the results of these tests may partly explain this improvement. They also suggest that the generally recognized good comparative keeping quality of the 1916 crop may have been due largely to the very general failure of the under berries to set in their usual abundance.

The deeper the scoops are run through the vines in picking, the greater the proportion of under berries that are gathered and the greater, also, the quantity of unattached cranberry leaves and sand that gets mixed with the fruit. On account of the inferior keeping quality of the under berries here shown, and because of the harm done by admixtures of loose leaves proved by tests described below (No. 7, page 206), the desirability of closely scooping berries that are to be stored long is rendered doubtful.

5. *Housing promptly* v. *Leaving Crates of Berries in the Sun on the Bog, as affecting Cranberry Keeping.* — Eight series of tests were carried out in this connection, four with Early Black and four with Howes fruit. Four of these were conducted in connection with the picking experiments described above (No. 3, page 197), Table 7 showing their arrangement and results. Dr. Stevens took all the temperatures given in this table with chemical thermometers, their bulbs being plunged to the centers of the crates. At 8 A.M., September 19, the temperatures of the twelve boxes of Early Black berries ranged from 68° to 70° F., and at 8 A.M., September 20, they ranged from 61° to 62°, from which there was little change for several days after.

The records in Table 7 show that as a rule the temperature of berries left in crates on the bog exposed to the sun for several hours did not change more than 3 degrees. The temperatures of some of these crates were taken every thirty minutes from the time they were picked until they were housed, almost no variation being discovered until very near the latter time. The averages of percentages given in the table indicate that the Early Black berries housed at once kept somewhat better than those left on the bog, whereas these results with the Howes fruit were reversed. This difference in the storage of the two varieties corresponded with the difference in the average temperatures of the different lots when housed, the Early Black berries housed at once averaging to have lower temperatures when placed in storage than did those left on the bog, whereas the Howes fruit housed at once had a somewhat higher average temperature when stored than did that left on the bog.

The four other experiments under this head were carried out in connection with some of the tests of the effect of wetness on cranberry keeping described below (No. 6 (*a*), page 201), Table 10 exhibiting their arrangement and results. As in the first four series of tests, Dr. Stevens took all the temperatures with chemical thermometers at the centers of the crates. It was partly cloudy all day the day that the Early Black berries used in these tests were picked. The averages of percentages in the table show that with both varieties the wet berries kept better after having been left on the bog, whereas the dry ones kept better when housed at once.

On the whole, the results of these tests were inconclusive, though they failed to show much harm to the keeping quality resulting from leaving the crated fruit on the bog for several hours under ordinary harvesting and storage conditions.

6. *Wet and Dry Cranberries compared as to Keeping.* — Three series of tests come under this head, as follows: —

(*a*) An area 60 feet square laid out on Early Black vines on the station bog was divided into equal parts by lines running diagonally between the corners. Two of the opposite triangles thus formed were scooped while the berries were wet with dew, the other two being left until they were dry. The ways in which these berries were tested and the results obtained are shown in test No. 1 of Table 10.

(*b*) An area 100 by 30 feet laid out on Howes vines on the station bog was divided into triangles by diagonal lines between the corners. Two opposite triangles were picked with scoops while the vines were more or less wet with dew, and the other two when they were dry. The manner of testing this fruit and the results obtained with it are shown in test No. 2 of Table 10.

TABLE 10. — *Effect of Wetness and of leaving Berries in the Sun on Cranberry Keeping.*

Test No. 1, Early Black Variety.

METHOD AND DATE OF PICKING.	Lot No.	Quantity of Fruit (Bushels).	In What Condition picked.	Housed at once or left on Bog in Sun.	Crate No.	Hour of Day picked.	Temperature of Berries when picked.	Hour of Day housed.	Temperature when housed.	Period of Storage Test.	Percentage of Rotten and Partly Rotten Berries found at End of Storage Test.	Averages of Percentages of Rotten and Partly Rotten Berries.	Averages of Percentages.
With scoops, Sept. 20,	A,	6	Wet,	Housed at once, .	1	10.15 A.M.	62° F.	10.45 A.M.	62° F.	Sept. 20 to Dec. 16	36.10	36.43	36.19
					2	10.15 A.M.	62° F.	10.45 A.M.	62° F.	Sept. 20 to Dec. 16	37.34		
					3	10.30 A.M.	66° F.	10.45 A.M.	66° F.	Sept. 20 to Dec. 15	35.85		
				Left on bog, .	4	10.00 A.M.	59° F.	3.00 P.M.	62° F.	Sept. 20 to Dec. 16	37.42	35.94	
					5	10.00 A.M.	59° F.	3.00 P.M.	62° F.	Sept. 20 to Dec. 16	34.54		
					6	10.30 A.M.	66° F.	3.00 P.M.	66° F.	Sept. 20 to Dec. 15	35.86		
	B,	6	Dry,	Housed at once, .	1	11.30 A.M.	81° F.	11.45 A.M.	81° F.	Sept. 20 to Dec. 16	16.82	22.60	23.05
					2	11.30 A.M.	81° F.	11.45 A.M.	81° F.	Sept. 20 to Dec. 16	25.66		
					3	11.30 A.M.	81° F.	11.45 A.M.	81° F.	Sept. 20 to Dec. 15	25.33		
				Left on bog, .	4	11.30 A.M.	81° F.	At sunset	79° F.	Sept. 20 to Dec. 16	21.63	23.50	
					5	11.30 A.M.	81° F.	At sunset	79° F.	Sept. 20 to Dec. 16	22.26		
					6	11.30 A.M.	81° F.	At sunset	79° F.	Sept. 20 to Dec. 16	26.61		
Test No. 2, Howes Variety.													
With scoops, Oct. 3, .	C,	6	Wet,	Housed at once, .	1	9.25 A.M.	69° F.	9.30 A.M.	69° F.	Oct. 3 to Dec. 14	13.47	15.08	13.50
					2	9.00 A.M.	63° F.	9.15 A.M.	63° F.	Oct. 3 to Dec. 15	14.38		
					3	9.00 A.M.	63° F.	9.15 A.M.	63° F.	Oct. 3 to Dec. 15	17.38		
				Left on bog, .	4	9.20 A.M.	68° F.	4.00 P.M.	73° F.	Oct. 3 to Dec. 15	9.63	11.92	
					5	9.15 A.M.	66° F.	4.00 P.M.	73° F.	Oct. 3 to Dec. 16	13.07		
					6	9.00 A.M.	64° F.	4.00 P.M.	73° F.	Oct. 3 to Dec. 15	13.06		
	D,	6	Dry,	Housed at once, .	1	10.00 A.M.	77° F.	10.00 A.M.	77° F.	Oct. 3 to Dec. 15	9.88	11.32	12.54
					2	10.00 A.M.	77° F.	10.00 A.M.	77° F.	Oct. 3 to Dec. 14	12.68		
					3	10.00 A.M.	77° F.	10.00 A.M.	77° F.	Oct. 3 to Dec. 15	11.40		
				Left on bog, .	4	10.00 A.M.	77° F.	4.00 P.M.	74° F.	Oct. 3 to Dec. 16	10.40	13.75	
					5	10.00 A.M.	77° F.	4.00 P.M.	74° F.	Oct. 3 to Dec. 15	15.29		
					6	10.00 A.M.	77° F.	4.00 P.M.	74° F.	Oct. 3 to Dec. 14	15.57		

The averages of percentages in the table show that the berries stored wet rotted more than those stored dry in both series of tests. The wet berries in the second series were more nearly dry when picked than were those of the first series, this apparently accounting for the smaller difference in the average amounts of rot that developed in the two lots of Howes fruit. The wet berries left on the bog were perhaps dried a good deal, as compared with those housed at once, by the high temperatures and free circulation of the open air, this perhaps explaining their better keeping.

All the berries in these tests were stored in bushel picking crates as they came from the bog, without cleaning in any way. Their rot percentages were determined by the "nine-sample" method.

(*c*) The two tests in the third series are fully explained by Table 11. The wet berries in these tests were considerably wetter than those in either of the first two series, the moisture being that of a very heavy dew. All the crates were stored as soon as the berries were picked. The temperatures given in the table were taken by the writer when the fruit was housed, chemical thermometers being plunged to the centers of the crates. When the four crates picked on October 4 were stored, the temperature of those picked the night before was 50° F. The temperatures of the wet and dry picked berries did not become equalized in storage until some time during the night of October 6 and 7.

All this fruit was stored without cleaning. The crates were examined by the "nine-sample" method.

TABLE 11. — *Effect of Wetness on Cranberry Keeping.*

Test No.	Lot No.	VARIETY.	Date picked.	Hour of Day picked.	How picked.	In what Condition picked.	Temperature at which picked.	Quantity of Fruit (Bushels).	How stored.	Period of Storage Test.	Percentage of Rotten and Partly Rotten Berries found at End of Storage Test.
1,	A,	Early Black, ...	Oct. 3	9 to 10 P.M.	Scooped.	Very wet.	38° F.	2	In picking crates, . .	Oct. 3 to Dec. 16	46.81
	AA,	Early Black, ...	Oct. 4	12 to 1 P.M.	Scooped.	Dry.	73° F.	2	In picking crates, . .	Oct. 4 to Dec. 16	24.31
2,	B,	Howes, ...	Oct. 3	9 to 10 P.M.	Scooped.	Very wet.	38° F.	2	In picking crates, . .	Oct. 3 to Dec. 16	41.47
	BB,	Howes, ...	Oct. 4	12 to 1 P.M.	Scooped.	Dry.	74° F.	2	In picking crates, . .	Oct. 4 to Dec. 16	17.68

TABLE 12. — *Effect of an Admixture of Cranberry Leaves on the Keeping of the Berries.*

Test No.	VARIETY OF BERRIES TESTED.	Date Berries were picked.	Period of Storage.	Lot No.	Quantity of Fruit placed in Storage (Bushels).	In what Condition stored.	Percentage of Rotten and Partly Rotten Berries found at End of Storage Test.
1,	Early Black,	Sept. 20	Sept. 20 to Dec. 18,	1	4	With neither vines nor leaves,[1]	33.74
				2	4	With vines and leaves attached,[2]	30.62
2,	Early Black,	Sept. 29	Sept. 29 to Dec. 18,	1	3	With neither vines nor leaves,	19.70
				2	3	With vines and leaves attached,	16.84
				3	3	With vines stripped of leaves,[3]	18.02
				4	3	With leaves only,[4]	25.17
3,	Howes,	Oct. 5	Oct. 5 to Dec. 19,	1	3	With neither vines nor leaves,	11.21
				2	3	With vines and leaves attached,	11.01
				3	3	With vines stripped of leaves,	9.96
				4	1	With leaves only,	14.83
4,	Howes,	Oct. 7	Oct. 7 to Dec. 18,	1	3	With neither vines nor leaves,	14.04
				2	3	With vines stripped of leaves,	12.56
				3	3	With leaves only,	20.95

[1] Fairly well cleaned of vines by hand.

[2] No vines taken out, but left just as they were poured out of the scoops.

[3] The bare cranberry vines, with the leaves removed, mixed in with the berries in considerable quantity.

[4] About a quart of green cranberry leaves stripped from the vines and mixed with the berries in each crate.

The table shows that the results of this test strongly confirmed those of the first two, giving striking evidence of the harmful effect of excessive moisture among cranberries in storage.

7. *Effects of Admixtures of Vines and Leaves on Cranberry Keeping.* — The four series of tests in this connection were carried out as shown in Table 12. The fruit was picked with scoops and was stored in bushel picking crates. The crates were examined by the "nine-sample" method.

The table shows that these tests gave convincing evidence of the harmful effect of an admixture of unattached cranberry leaves in the storage of the fruit. They also indicated that the berries keep as well with the admixture of vines and leaves attached, commonly obtained in scooping, as any way. The entire removal of the vines and leaves, aside from the injury done in the process, however, seems to do no harm.

8. *Berries separated with Hayden and with White Machines and Berries screened without separating compared as to Keeping Quality.* — The berries used in these two series of tests were handled throughout in the same way. The three lots of fruit in each series came from the same source, individual crates of berries as they came from the bog being divided as evenly as possible into three separate parts by successive pourings into barrels to produce them, care being taken to handle the berries of the different lots as nearly alike as possible. As there was no White separator in working order in East Wareham at the time, all this fruit was carted in open barrels in a farm wagon (without springs) to the Makepeace screenhouse at Wareham, two of the lots of each series being there run through Hayden and White separators, respectively. The berries were received into barrels from both the Hayden and the White machines, those of the first box (the "good" box) also being used in the test in the case of the former. The berries of all the lots were carted back in the open barrels to the station screenhouse, where they were hand-screened, the fruit in all cases being received into picking crates placed close to the mouths of the screens and being stored in those crates. The arrangement and results of these tests are shown in Table 13. The "nine-sample" method was used in examining the crates.

TABLE 13. — *Injury to Keeping Quality of Cranberries caused in Separating. — Hayden v. White Separators.*

VARIETY.	Quantity of Fruit placed in Storage Test (Bushels).	How cleaned.	Date separated.	Date screened.	Date examined to determine Rot Percentage.	Percentage of Rotten and Partly Rotten Berries at End of Storage Test.
Howes,	4	Hand-screened only,	-	Oct. 26	Dec. 21,	12.59
	4	Hayden separator and hand-screened,	Oct. 25	Oct. 26	Dec. 20 and 21,	14.46
	4	White separator and hand-screened,	Oct. 25	Oct. 26	Dec. 20 and 21,	14.19
McFarlin,	4	Hand-screened only,	-	Oct. 26	Dec. 20 and 21,	12.34
	4	Hayden separator and hand-screened,	Oct. 25	Oct. 26	Dec. 20 and 21,	19.20
	4	White separator and hand-screened,	Oct. 25	Oct. 26	Dec. 20 and 21,	19.36

The figures of the table indicate that, in both tests, the White machine apparently affected the keeping qualities of the fruit about the same as did the Hayden. This result is surprising, and must be verified by future experiments. The difference in the tendency to rot between the separated and unseparated berries was not as great as in last year's tests. This may have been partly due to the injury that all the lots of fruit probably received in the carting, this perhaps partly hiding the real difference in the damage done by the various methods of cleaning.

9. *The Injury to the Keeping Quality of Cranberries caused by Separators employing the Bouncing Principle and by the Drop in the Barrel.* — That this varies greatly with different lots of berries was indicated by the results of half a dozen minor experiments conducted by Dr. Stevens. The range in the increase of decay caused by these factors in these tests was from about 14 to about 127 per cent.

A new arrangement devised by the writer for preventing the barrel injury, for use both in screening and in connection with separators, works well mechanically and promises to be generally satisfactory, though no storage tests have been conducted to determine the degree of its effectiveness. This device is on exhibition at the offices of the New England Cranberry Sales Company, Middleborough, Mass., and the J. J. Beaton Growers' Agency, Wareham, Mass., and it also may be seen at the station screenhouse at East Wareham at any time during the cranberry season.

10. *The Effect of Grading on the Keeping of Cranberries.* — The two following series of tests come under this head: —

(*a*) Two lots of Early Black berries picked in the same location on the station bog were treated as shown in Table 14. To make sure of their being well cleaned they were run through a Hayden separator twice immediately before they were stored. Only the berries going into the separator barrels were used in the test. Neither lot was hand-screened. They were stored in bushel picking crates of the same dimensions and construction. The Hayden grader was used. A board was in the grader frame in place of the grader while the second lot was run through. The spacing of the grader, fourteen thirty-seconds of an inch, was wider than that commonly used, and it took out from a fifth to a quarter of the entire quantity of berries put through the separator while it was in use.

TABLE 14. — *Effect of Grading on Keeping of Cranberries, First Test (Early Black Variety).*

Date picked.	Date put through Separator.	Lot Number.	Whether graded or not.	Spacing of Grader used (Inches).	Quantity of Berries placed in Storage Test (Bushels).	Period of Storage Test,	Average Cup-count of Berries at End of Storage Test.	Method of Examination to determine Rot Percentage.	Percentage of Rotten and Partly Rotten Berries found at End of Storage Test.
Oct. 2	Oct. 21	1,	Graded, . . .	$\frac{14}{32}$	3	Oct. 21 to Dec. 27	114.3	Nine-sample, . .	28.51
		2,	Not graded, . . .	-	3	Oct. 21 to Dec. 27	122.8	Nine-sample, . .	34.69

The figures of the table show that the closely graded berries kept considerably better than the ungraded ones, there being nearly 22 per cent. more rot among the latter at the close of the test. The cup-counts were taken with the inspectors' cup of the New England Cranberry Sales Company.

(*b*) Two lots of Howes berries were obtained for this series of tests by dividing boxes of fruit, just as they had been stored when they came from the bog on October 7, into equal parts by alternate dippings with a quart measure. They were put through a Hayden separator, with the upper set of bounce-boards set at the middle notch, on December 26. A board five-eighths of an inch thick was kept in the grader frame in place of the grader while the second lot was run through. The grader took out about a quarter of the quantity of berries separated while it was in use. Only the berries that went into the barrels from the separator were used. They were poured from the barrels into boxes and were taken into the warm screening room a box at a time, so that they might undergo a high temperature no longer than necessary during the screening. Both lots were carefully screened at the same time on December 29, the berries being run into picking crates placed close to the mouths of the screens. They were carefully shaken down and stored in these crates at once. The arrangement and results of these tests are shown by Table 15.

It will be seen that after a winter storage of nearly ten weeks almost 32 per cent. more berries showed rot among the ungraded fruit than among that which had been closely graded. At no time during the test did the temperature of the storage room range more than 8° above the freezing point of water, and for considerable periods it ran more or less below it. The cup-counts given in the table were taken, as in the first series of tests, with the Sales Company's cup.

While it cannot safely be said that the results of these tests prove that grading improves the keeping of cranberries, they bring out a point of much importance. Closely graded berries, being larger and more uniform in size, are much more desirable in appearance than ungraded ones. If they also keep better, the advisability of preparing them for market in this way as a means of inducing greater consumption is much confirmed. If close grading were generally practiced it could be made a powerful factor in properly controlling the cranberry market, for, while it tended strongly to increase consumption on one hand, it would in a sense cut down production on the other. In the writer's opinion it would be the best possible means for dealing with overproduction, for if any part of a crop had to be thrown away it would be only the berries of inferior size or quality.

The results of these grading tests are entirely in line with last year's findings of the writer, in the study of ventilation as affecting cranberry keeping, and with those brought out by Dr. Shear and his collaborators in their paper published as a part of this bulletin. The small berries as well as the leaves, conclusive experiments with which are described above (No. 7, page 206), might be expected to check ventilation, not only by

TABLE 15. — *Effect of Grading on Cranberry Keeping, Second Test (Howes Variety).*

Lot No.	WHETHER GRADED OR NOT.	Spacing of Grader used.	Quantity of Berries placed in Storage Test (Bushels).	Period of Storage Test.	Method of Examination to determine Rot Percentage.	Box Number.	Average Cup-count of Berries at End of Storage Test.	Percentage of Rotten and Partly Rotten Berries found at End of Storage Test.
1,	Graded, . . .	Half-inch, . . .	4	Dec. 29 to Mar. 7, . .	Seven-sample, . .	1	95.3	22.0
						2	96.7	17.6
						3	95.0	20.2
						4	97.1	21.9
							96.0[1]	20.4[1]
2,	Not graded, . . .	. .	5	Dec. 29 to Mar. 7, . .	Seven-sample, . .	1	104.9	27.0
						2	106.6	33.2
						3	103.6	26.5
						4	108.1	24.8
						5	106.3	23.0
							105.9[1]	26.9[1]

[1] Average.

mechanically reducing the spaces for the passage of air and gases among the fruit, but also by themselves using up oxygen and giving off additional carbon dioxide, in this way being especially harmful.

11. *The Relative Effect of Barrel and Crate Containers on Cranberry Keeping in Shipments.* — Three lots of Early Black and two lots of Howes berries, each lot consisting of a barrel and two half-barrel crates, made up an experimental shipment to determine this. All the berries of each lot came from the same place on the station bog, the different lots being picked in various locations, the Early Black on October 2 and the Howes on October 5. All five lots were run through a Hayden separator and screened on November 7. On account of difficulties encountered in arranging for shipping this fruit with other berries in a carload, it was then kept in open barrels, all of which were nearly full, until November 17, when it was packed for shipment. The berries shipped in barrels were packed in the usual way, while the crated fruit was placed in 4-quart baskets like those used as containers for strawberries.[1] All the lots were left in the packed condition in a cold room until November 20, when they were carted in a farm wagon (without springs) from East Wareham to Tremont Station. They were kept in the railroad freight-house over night and placed in different parts of a car on top of a carload of other berries the next morning. The car left Tremont November 21 and arrived in Washington, D. C., on Saturday, November 25. They were there left in the freight-house until the following Monday morning. They were then taken to Arlington Farm and stored at a temperature of about 50° F. until December 9. The barrels and crates were opened and stored in a laboratory, the temperature of which varied from 60° to 85° F., from December 9 until December 14 and 15, when they were sampled and examined, as follows: —

(*a*) The eight following samples were taken from each barrel: —

Nos. 1 and 2, two quarts near the top, just below the layer crushed in heading, — distinguished in Table 16 by the word "top."

No. 3, one quart taken a quarter of the distance down from the top, — indicated by "¼".

Nos. 4 and 5, two quarts taken near the middle, — marked "½".

No. 6, one quart taken from three-quarters of the distance from the top toward the bottom, — designated as "¾".

Nos. 7 and 8, two quarts from near the bottom, — distinguished as "bottom."

The berries were dipped out of the barrels down to the parts sampled, the samples being taken from all parts of the surface of the fruit exposed by the dipping, except within 2 inches of the staves.

(*b*) Four 1-quart samples were taken from each crate of each lot at various places in the crate, so as to make up as fair an average as possible, each sample representing different baskets.

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[1] The crates and baskets were furnished through the courtesy of Mr. J. J. Beaton of Wareham, Mass.

TABLE 16. — *Barrels v. Crates as Containers for Shipping Cranberries. Record of Examination of Experimental Lots shipped to Washington, D. C.*

SAMPLES.	SHIPMENT — LOTS.														
	1. EARLY BLACK.			2. EARLY BLACK.			3. EARLY BLACK.			4. HOWES.			5. HOWES.		
	Number of Sound Berries in the Sample.	Number of Rotten and Partly Rotten Berries in the Sample.	Percentage of Rotten and Partly Rotten Berries.	Number of Sound Berries in the Sample.	Number of Rotten and Partly Rotten Berries in the Sample.	Percentage of Rotten and Partly Rotten Berries.	Number of Sound Berries in the Sample.	Number of Rotten and Partly Rotten Berries in the Sample.	Percentage of Rotten and Partly Rotten Berries.	Number of Sound Berries in the Sample.	Number of Rotten and Partly Rotten Berries in the Sample.	Percentage of Rotten and Partly Rotten Berries.	Number of Sound Berries in the Sample.	Number of Rotten and Partly Rotten Berries in the Sample.	Percentage of Rotten and Partly Rotten Berries.
Barrel samples: —															
1 (top),	379	236	38.4	385	205	34.7	398	131	24.8	321	84	20.7	397	97	19.6
2 (top),	374	234	38.5	398	224	36.0	393	172	30.5	329	83	20.1	373	121	24.5
3 (¼),	308	246	44.4	340	211	38.3	289	212	42.3	387	129	25.0	428	81	15.9
4 (½),	327	210	39.1	397	190	33.4	355	205	36.6	379	107	21.2	421	84	16.6
5 (½),	310	240	43.6	309	235	43.2	373	178	32.3	342	156	31.3	418	96	18.7
6 (¾),	290	224	43.6	323	237	42.3	282	276	49.5	388	125	24.4	410	95	18.8
7 (bottom),	356	196	35.3	347	216	38.4	324	232	41.7	404	110	21.4	420	98	18.9
8 (bottom),	354	159	31.0	368	209	36.2	325	205	38.7	392	113	22.4	399	113	22.1
Totals of barrel samples,	2,698	1,745	39.3	2,849	1,727	37.7	2,739	1,611	37.0	2,960	907	23.5	3,266	785	19.4
Crate samples: —															
1,	404	147	26.7	391	192	32.9	380	134	26.1	468	53	10.2	499	37	6.9
2,	401	167	29.4	404	184	31.3	443	121	21.5	473	84	15.1	495	39	7.3
3,	395	121	23.5	406	210	34.1	405	137	25.3	417	76	15.4	499	62	11.0
4,	402	151	27.3	397	186	31.9	430	191	30.8	471	53	10.1	462	30	6.1
5,	410	172	29.6	433	121	21.8	397	187	32.0	468	68	12.7	478	45	8.6
6,	415	190	31.4	382	191	33.3	441	140	24.1	464	62	11.8	460	34	6.9
7,	403	169	29.6	387	176	31.3	397	155	28.1	454	69	13.2	492	38	7.2
8,	424	144	25.3	403	166	29.2	399	150	27.3	443	77	14.8	442	72	14.0
Totals of crate samples,	3,254	1,261	27.9	3,203	1,426	30.8	3,292	1,215	27.0	3,658	542	12.9	3,827	357	8.5
Percentage of berries showing decay in the barrels as compared with those in the crates,	141			122			137			182			228		

The sampling was done by Dr. Stevens. The results of his examinations are given in Table 16. They show that the crated fruit was in much better condition than that in barrels in all the lots, especially those of the Howes variety.

The results of these tests accord with the conclusions given in last year's report (pages 23 and 24) regarding the use of crates instead of barrels as shipping containers for cranberries. These results were confirmed by those obtained with shipments of berries from another bog to Portland, Me., made by Dr. Stevens, but not described here.

12. *The Relative Development of Decay in Different Periods of the Storage Season.* — The four series of tests to determine this were conducted as follows: —

(*a*) On September 22, 20 quart cans were filled with entirely sound berries from each of 7 half-filled crates of Early Black fruit picked at the same time in the same general location on the station bog three days before. This fruit was stored at once, and the different 20-can lots were examined one after another at intervals of two weeks.

(*b*) On October 4, 10 quart cans were filled with sound berries from each of 12 half-filled crates of Howes fruit picked at the same time and in the same place on the station bog the day before. These cans were stored at once, and the different 10-can lots were examined one after another at weekly intervals.

(*c*) Quart cans were filled with sound Early Black fruit in lots of 10, from each of 13 half-filled crates successively, at weekly intervals from September 20 to December 13, inclusive, the berries all having been picked at the same time and in the same general location on the station bog on September 19. The cans of each lot were stored as soon as filled and were examined at the end of a two-week storage.

(*d*) Quart cans were filled with sound Howes fruit in lots of 10, from each of 11 half-filled crates successively, at weekly intervals from October 4 to December 13, inclusive, the berries all having been picked at the same time and in the same location on the station bog on October 3. The cans of each lot were stored as soon as filled and were examined at the end of a two-week storage.

The arrangement and results of all these series of tests are given in order in Table 17. They failed to show any distinct difference in the rate of rot development in the various periods of the storage season, this general result differing from that of last year's experiment [1] in this connection. The writer now thinks that the handling of the berries in selecting them for these tests, and their lack of ventilation in the tightly covered cans, may have so affected their keeping as to hide different results that perhaps would have been obtained under more normal storage conditions. The description of the tests is included here for its possible value in making future comparisons, and as a record of work done. Further experiments along this line should be tried.

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[1] Bul. No. 168, Mass. Agr. Expt. Sta., 1916, p. 18.

TABLE 17. — *Rot Development among Cranberries stored in Tin Cans in Different Periods of the Storage Season.*

TEST AND VARIETY.	Quantity of Berries used (Quarts).	Date stored.	Date examined to determine Rot Percentage.	Total Number of Berries.	Number of Rotten and Partly Rotten Berries when examined after Storage.	Percentage of Rotten and Partly Rotten Berries found at End of Storage.
(*a*), Early Black, . . .	20	Sept. 22	Oct. 6	11,415	450	3.94
	20	Sept. 22	Oct. 20	11,641	1,516	13.02
	20	Sept. 22	Nov. 3	11,506	3,069	26.67
	20	Sept. 22	Nov. 17	11,630	4,167	35.83
	20	Sept. 22	Dec. 1	11,781	5,118	43.44
	20	Sept. 22	Dec. 15	11,599	6,316	54.45
	20	Sept. 22	Dec. 29	11,412	6,532	57.24
(*b*), Howes, ...	10	Oct. 4	Oct. 11	4,903	71	1.45
	10	Oct. 4	Oct. 18	4,905	100	2.04
	10	Oct. 4	Oct. 25	4,960	228	4.60
	10	Oct. 4	Nov. 1	4,961	418	8.43
	10	Oct. 4	Nov. 8	4,888	503	10.29
	10	Oct. 4	Nov. 15	4,981	776	15.58
	10	Oct. 4	Nov. 22	4,948	860	17.38
	10	Oct. 4	Nov. 29	4,877	939	19.25
	10	Oct. 4	Dec. 6	4,894	1,147	23.44
	10	Oct. 4	Dec. 13	5,029	1,494	29.71
	10	Oct. 4	Dec. 20	4,821	1,353	28.06
	10	Oct. 4	Dec. 27	4,845	1,553	32.05
(*c*), Early Black, . . .	10	Sept. 20	Oct. 4	5,779	301	5.21
	10	Sept. 27	Oct. 11	5,530	308	5.57
	10	Oct. 4	Oct. 18	5,602	137	2.45
	10	Oct. 11	Oct. 25	5,782	222	3.24
	10	Oct. 18	Nov. 1	5,441	240	4.41
	10	Oct. 25	Nov. 8	5,363	140	2.61
	10	Nov. 1	Nov. 15	5,379	201	3.74
	10	Nov. 8	Nov. 22	5,487	220	4.01
	10	Nov. 16	Nov. 30	5,693	295	5.18
	10	Nov. 22	Dec. 6	5,684	315	5.54
	10	Nov. 29	Dec. 13	5,510	307	5.57
	10	Dec. 6	Dec. 20	5,763	304	5.28
	10	Dec. 13	Dec. 27	5,513	476	8.63

TABLE 17. — *Rot Development among Cranberries stored in Tin Cans in Different Periods of the Storage Season* — Concluded.

TEST AND VARIETY.	Quantity of Berries used (Quarts).	Date stored.	Date examined to determine Rot Percentage.	Total Number of Berries.	Number of Rotten and Partly Rotten Berries when examined after Storage.	Percentage of Rotten and Partly Rotten Berries found at End of Storage.
(*d*), Howes, ...	10	Oct. 4	Oct. 18	4,643	118	2.54
	10	Oct. 11	Oct. 25	4,730	104	2.20
	10	Oct. 18	Nov. 1	4,908	191	3.89
	10	Oct. 25	Nov. 8	4,570	117	2.56
	10	Nov. 1	Nov. 15	4,546	103	2.27
	10	Nov. 8	Nov. 22	4,633	129	2.78
	10	Nov. 15	Nov. 29	4,808	116	2.41
	10	Nov. 23	Dec. 7	4,747	112	2.36
	10	Nov. 29	Dec. 13	4,915	145	2.95
	10	Dec. 6	Dec. 20	4,943	155	3.14
	10	Dec. 13	Dec. 27	4,849	142	2.93

13. *Incubator Test of Keeping Quality of Cranberries.* — A few lots of Early Black berries were moistened and tested as to their keeping quality in quart cans, with the covers on tight but not sealed, in a chicken incubator run at a temperature of 80° F. The results seemed to show that the relative keeping quality of cranberries can be determined in this way in a period of about forty-eight hours.

Tentative Practical Conclusions based on the Results of the Storage Tests.

1. Cranberries should not be picked wet.
2. Scoop-picking is not particularly harmful to keeping quality.
3. Deep scooping is likely to affect cranberrry keeping adversely because it gathers maximum amounts of under berries, loose leaves and sand, these materials being harmful in storage.
4. Cranberries left in the sun on the bog for a good part of the day during picking seem to keep about as well as those housed at once, under average storage-house conditions. There might be a great difference in this regard, however, if cooler storage were practiced, for the relatively high temperature usually had by the berries when they are picked probably has a hurtful effect, hence the sooner they are cooled the better.
5. Lack of sufficient ventilation affects cranberry keeping adversely, apparently by interfering with the process of respiration, not by prevent-

ing the evaporation of moisture, as suggested in last year's report (pages 6 to 17). Cranberries, like other fruits, are living, breathing organisms when picked, and must take in oxygen and give off carbon dioxide freely to continue their life processes. They may do this for several months after they are taken from the vines. Lack of ventilation probably affects them in much the same way that smothering does an animal, — by permitting the accumulation of the carbon dioxide gas given off by their tissues and thus reducing their supply of oxygen. The harmful effect of the carbon dioxide appears to be pretty well demonstrated by the experiments described by Dr. Shear and his associates in another part of this bulletin (page 237). This gas appears to collect in injurious quantities among cranberries, both in storage and shipment, because of the closeness with which the fruit packs together and of the size of the containers used.

As has been so splendidly demonstrated with apples,[1] the rapidity of the life processes in fruits varies directly with temperature, much more carbon dioxide being given off at high than at low temperatures. While cranberries may not behave exactly as apples do, it seems to follow that low temperatures are important to cranberry keeping both in storage and shipment, for with such temperatures the need of ventilation is probably less.

The general problem divides itself naturally into two parts, as follows: —

(*a*) *Storage previous to Shipment* — Low temperatures, because of their retarding effect on the process of respiration and on the growth of rot-producing fungi, seem most important. The storage house, therefore, probably should be constructed and managed to maintain such temperatures, without resorting to artificial cold storage, at as little expense as possible. This in turn, however, is likely in practice to depend largely on arrangements for free but controllable ventilation. If, as the results of the experiments described by Dr. Shear and his collaborators on page 238 seem to tend to show, a damp atmosphere does not injure the keeping of this fruit, the thorough ventilating of the storage room during the night and on cold days would be the cheapest means of obtaining low temperatures, and they probably should be maintained as far as possible by the use of dead-air spaces in the walls. To combine satisfactory arrangements for free but controllable ventilation and for effective heat insulation at a reasonable expense is probably, therefore, the main problem to be solved by future builders of cranberry storage houses. Artificial cold storage for cranberries has not been investigated much yet, and therefore is not considered here.

(*b*) *Preparation for Shipment.* — While a low temperature is still probably desirable for cranberries after they leave the producer, this factor, except as it may be utilized by cooling previous to shipment or by shipping in refrigerator cars, is largely out of his control. He should, therefore, make the most of careful handling of the fruit in packing and of proper ventilation for it while in transit and in the market. The latter seems to call especially for close grading and for the use of as small and open containers as practicable.

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[1] F. W. Morse, Bul. No. 135, New Hampshire Agr. Expt. Sta., 1908, and Journal of the American Chemical Society, Vol. 30, No. 5, 1908.

6. The separator problem is still unsolved.

RESANDING.

The year's experience with the plots, results with which have been discussed in previous reports, is shown in Table 18. The check areas were in each case laid out adjacent to and on opposite sides of the plot. All the plots and checks were picked with scoops. The storage-test berries were selected by handfuls from different parts of the crates as they came from the bog and put in quart cans, each can representing one crate. The cans were stored with covers on tight but not sealed.

This, the seventh year since resanding was discontinued on plots O and V, is the first one except 1913 in which their yield has been noticeably reduced as compared with that of the checks. Throughout the season these unsanded plots presented a marked contrast to the surrounding bog which was resanded in 1912 and 1914, their vines being comparatively very thin and sickly in appearance.

TABLE 18. — *Sanding Plots in 1916. Effect of Resanding on Quantity and Keeping Quality of Cranberries.*

PLOTS AND CHECKS.	Area (Square Rods).	Variety.	When resanded.	Date picked.	Quantity of Fruit obtained (Bushels).	Quantity of Fruit per Square Rod (Bushels).	Quantity placed in Storage Test (Quarts).	Period of Storage Test.	Percentage of Rotten and Partly Rotten Berries found at End of Storage Test.
V,	9	Early Black,	Not since November, 1909,	Sept. 27	8.33	.93	8	Sept. 27 to Nov. 27	62.76
V (check 1),	9	Early Black,	Spring of 1912 and fall of 1914,	Sept. 27	13.33	1.48	8	Sept. 27 to Nov. 27	54.01
V (check 2),	6	Early Black,	Spring of 1912 and fall of 1914,	Sept. 27	9.00	1.50	8	Sept. 27 to Nov. 27	55.26
V (check 3),	9	Early Black,	Spring of 1912 and fall of 1914,	Sept. 27	10.60	1.18	8	Sept. 27 to Nov. 28	58.88
O,	9	Early Black,	Not since November, 1909,	Sept. 26	8.33	.93	8	Sept. 26 to Nov. 28	54.46
O (check 1),	9	Early Black,	Fall of 1911 and fall of 1914,	Sept. 26	13.00	1.44	8	Sept. 26 to Nov. 28	31.74
O (check 2),	7½	Early Black,	Fall of 1911 and fall of 1914,	Sept. 26	8.13	1.08	8	Sept. 26 to Nov. 28	50.89
O (check 3),	9	Early Black,	Fall of 1911 and fall of 1914,	Sept. 26	10.67	1.19	8	Sept. 26 to Nov. 29	45.48
N,	9	Early Black,	Yearly in the fall, 1911 to 1915, inclusive,	Sept. 28	12.25	1.36	8	Sept. 28 to Nov. 23	37.63
N (check 1),	9	Early Black,	Fall of 1911 and fall of 1914,	Sept. 28	12.50	1.39	8	Sept. 28 to Nov. 23	33.38
N (check 2),	9	Early Black,	Fall of 1911 and fall of 1914,	Sept. 28	14.25	1.58	8	Sept. 28 to Nov. 23	37.35
N (check 3),	9	Early Black,	Fall of 1911 and fall of 1914,	Sept. 28	13.50	1.50	8	Sept. 28 to Nov. 23	38.92
R,	9	Early Black,	Yearly in the fall, 1911 to 1915, inclusive,	Sept. 25	9.13	1.01	8	Sept. 25 to Nov. 25	37.12
R (check 1),	5	Early Black,	Fall of 1911 and fall of 1914,	Sept. 25	6.50	1.30	8	Sept. 25 to Nov. 25	27.75
R (check 2),	6	Early Black,	Fall of 1911 and fall of 1914,	Sept. 25	6.83	1.14	8	Sept. 25 to Nov. 25	31.67
T,	9	Howes,	Yearly in the fall, 1911 to 1915, inclusive,	Oct. 4	11.17	1.24	8	Oct. 4 to Nov. 21	21.55
T (check 1),	9	Howes,	Fall of 1911 and fall of 1914,	Oct. 4	10.67	1.19	8	Oct. 4 to Nov. 21	19.98
T (check 2),	9	Howes,	Fall of 1911 and fall of 1914,	Oct. 4	13.60	1.51	8	Oct. 4 to Nov. 21	18.87

Summary of Table 18.

PLOTS AND CHECKS.	Total Area (Square Rods).	When resanded.	Total Quantity of Fruit picked (Bushels).	Average Quantity of Fruit per Square Rod (Bushels).	Average Percentage of Rotten and Partly Rotten Berries at End of Storage Test.
Plots O and V, .	18	Not since November, 1909,	16.66	.93	58.61
Checks O and V, .	49½	Twice since 1909, . .	64.73	1.31	49.38
Plots N, R and T, .	27	Yearly in the fall, 1911 to 1915, inclusive.	32.55	1.21	32.10
Checks N, R and T,	56	Twice since 1909, . .	77.87	1.39	29.70

The keeping qualities of the fruit of the sanding plots and their checks were determined by storage tests each year from 1912 to 1916, inclusive. The results of these tests and their averages are given in the following table: —

TABLE 19. — *Effect of Resanding on Keeping Quality.*

PLOTS AND CHECKS.	Variety.	Area (Square Rods).	When resanded.	PERCENTAGES OF ROTTEN AND PARTLY ROTTEN BERRIES AT END OF STORAGE TESTS.					
				1912.	1913.	1914.	1915.	1916.	Average for the Five Years.
V,	Early Black,	9	Not since 1909,	15.60	36.75	30.39	29.32	62.76	34.96
V (checks),	Early Black,	13½ to 24	Spring of 1912 and fall of 1914,	18.75	41.20	23.53	29.62	56.05	33.83
O,	Early Black,	9	Not since 1909,	15.30	29.40	27.94	19.95	54.46	29.41
O (checks),	Early Black,	18 to 25½	Fall of 1911 and fall of 1914,	21.90	28.90	31.37	23.79	42.70	29.73
N,	Early Black,	9	Yearly in the fall, 1911 to 1915, inclusive,	Not started	38.25	24.51	19.21	37.63	29.90
N (checks),	Early Black,	12 to 27	Fall of 1911 and fall of 1914,	-	30.14	19.61	17.70	36.55	26.00
R,	Early Black,	9	Yearly in the fall, 1911 to 1915, inclusive,	Not started	36.00	24.51	20.86	37.12	29.62
R (checks),	Early Black,	6 to 12	Fall of 1911 and fall of 1914,	-	34.20	24.51	17.25	29.71	26.42
T,	Howes,	9	Yearly in the fall, 1911 to 1915, inclusive,	Not started	38.75	18.14	13.53	21.55	22.99
T (checks),	Howes,	15 to 24	Fall of 1911 and fall of 1914,	-	29.40	13.73	13.65	19.43	19.05

FERTILIZERS.

The season's results with the station bog fertilizer plots are given in Table 20. The area of each plot, as stated in the report for 1912, is 8 square rods, and the variety of berries tested is the Early Black. The plots are on a peat bog with a covering of sand ranging from 6 to 8 inches in thickness.

TABLE 20. — *Fertilizer Plots in 1916. Yield and Relative Keeping Quality of Berries.*

Plot.	FERTILIZER USED.	Date treated in 1916.	Date picked.	Quantity of Berries produced (Bushels).	Quantity of Berries in Storage Test (Quarts).	Date Stored Berries were examined to determine Rot Percentage.	Percentage of Rotten and Partly Rotten Berries found at End of Storage Test.
1	0,	– –	Sept. 22	10.67	8[1]	Dec. 4	46.86
2	N,	June 24	Sept. 22	9.33	8	Dec. 4	50.21
3	P,	June 24	Sept. 22	9.00	8	Dec. 4	45.90
4	K,	June 24	Sept. 22	9.60	8	Dec. 4	53.78
5	0,	– –	Sept. 22	9.20	8	Dec. 4	49.61
6	NP,	June 24	Sept. 22	6.33	8	Dec. 5	57.64
7	NK,	June 24	Sept. 22	6.60	8	Dec. 5	56.33
8	PK,	June 26	Sept. 22	8.00	8	Dec. 7	49.00
9	0,	– –	Sept. 22	9.00	8	Dec. 7	45.14
10	NPK,	June 27	Sept. 22	6.88	8	Dec. 7	43.80
23	Peat[2],	– –	Sept. 22	8.00	8	Dec. 9	39.39
11	NPKL,	June 27	Sept. 23	2.86	8	Dec. 7	59.07
12	NPKcl,	June 27	Sept. 23	6.00	8	Dec. 7	50.98
13	0,	– –	Sept. 23	7.67	8	Dec. 8	41.12
14	$N_{1\frac{1}{2}}PK$,	June 26	Sept. 23	5.50	8	Dec. 8	55.84
15[3]	N_2PK,	June 26	Sept. 23	4.52	12	Dec. 8	63.10
16	$NKP_{1\frac{1}{2}}$,	June 26	Sept. 23	7.20	8	Dec. 8	55.81
17	0,	– –	Sept. 23	9.33	8	Dec. 8	39.87
18	NKP_2,	June 26	Sept. 23	8.33	8	Dec. 8	47.36
19	$NPK_{1\frac{1}{2}}$,	June 26	Sept. 23	7.75	8	Dec. 8	53.08
20	NPK_2,	June 26	Sept. 23	9.00	8	Dec. 8	59.94
21	0,	– –	Sept. 23	10.33	8	Dec. 8	49.63

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[1] The storage-test berries from each plot were stored, without being run through a separator or otherwise cleaned, in quart cans on the day they were picked, each can being filled with handfuls of fruit taken from different parts of a separate picking crate, its contents thus representing as fairly as possible the contents of the crate as it came from the bog. The covers of the cans fitted tightly during the storage, but were not sealed.

[2] Leaf mold worked into a condition in which it could be spread easily with a shovel.

[3] The figures for plot 15 are probably misleading, as half of that plot was used in spraying tests with Bordeaux mixture in 1913, 1914 and 1915, and certain effects of that treatment may have remained in 1916; though, if the whole plot had yielded at the same rate as did the portion that never had been sprayed, it would have produced only 5.33 bushels. The rot percentage given for this plot is an average of the percentages obtained in the tests of the fruit of the sprayed and the unsprayed parts.

Plots 1, 5, 9, 13, 17 and 21 are all untreated checks. The meanings of the symbols used in the table are as follows: —

0 = Nothing.
N = 100 pounds nitrate of soda per acre.
P = 400 pounds acid phosphate per acre.
K = 200 pounds high-grade sulfate of potash per acre.
L = 1 ton of (slaked) lime per acre.
Kcl = 200 pounds muriate of potash per acre.
$N_{1\frac{1}{2}}$ = 150 pounds nitrate of soda per acre.
N_2 = 200 pounds nitrate of soda per acre.
$P_{1\frac{1}{2}}$ = 600 pounds acid phosphate per acre.
P_2 = 800 pounds acid phosphate per acre.

In combination they mean, for example, as follows: N_2PK = 200 pounds of nitrate of soda + 400 pounds of acid phosphate + 200 pounds of high-grade sulfate of potash per acre.

As the table shows, the fruit of the fertilized areas this season was, as a rule, much inferior in both quantity and keeping quality to that of the checks, this being especially marked with the plots treated with lime and with the maximum amount of nitrate of soda. Considering all the experience with these plots since they were started in 1911, it is the writer's judgment that, in general, whatever slight advantage in yield has been gained by the use of the fertilizers has been balanced by the cost of the treatment, the deterioration in the quality of the fruit and the greater cost of picking due to the increased vine growth.

INSECTS.

The Cranberry Rootworm (*Rhabdopterus picipes* (Oliv.)).

The rearing of the beetles definitely identified the infestation by the cranberry rootworm (*Rhabdopterus picipes* (Oliv.)) tentatively recorded in last year's report (pages 32 and 33). By the beginning of winter the grubs of this insect nearly complete their growth. They are then, except the head, for the most part nearly white in color and somewhat over a quarter of an inch long. They hibernate without growing larger. They do some feeding in the spring and change into pupæ in June. No beetles of the infestation under observation had yet emerged on June 30, this season, a collection of the insects taken that day consisting of 4 grubs and 32 pupæ. One beetle was found on July 1, and during the following two weeks they practically all came out, the period of most rapid emergence extending from the 3d to the 11th of the month.

It was anticipated that the adults might feed freely on the cranberry foliage, and at the writer's suggestion an arsenical spray was applied to the infested area on July 3 and repeated on the 11th and 18th. In the first two applications, 2¼ pounds of "Corona" arsenate of lead and 1 heaping teaspoonful of white arsenic to 40 gallons of water were used. For the last treatment the mixture was the same, except that the arsenic was increased to 1½ teaspoonfuls to 40 gallons. The writer suggested only the arsenate of lead, fearing arsenic would do harm. The latter was added by the foreman of the bog to do a thorough job, and fortunately no injury resulted.

The writer visited the bog on July 20 and found dead rootworm beetles in large numbers under the vines, most of them being in a dry and brittle condition. Only a very few were crawling about. The cranberry foliage on the infested area showed that the beetles had fed freely upon it. As 6 of 15 beetles, collected July 11 and kept at the station screenhouse, were still active on the 26th, the condition of those found on the bog on the 20th seemed to indicate that the spraying had been effective. This bog was kept under observation until the end of the season, and no evidence of the continued presence of the pest was discovered, it having been practically exterminated by the treatment.

Prof. H. B. Scammell has published a valuable bulletin on this insect.[1]

The Gypsy Moth (*Porthetria dispar* L.).

Several quarts of egg masses were collected from trees late in December, 1915, and early in January, 1916, and divided into lots of about a half quart each, two of these being put in cans with moist sand in the bottom and placed in the basement of the station screenhouse for checks, the others being enclosed in cloth netting sacks and submerged for the winter in 3 feet of water in a pond.

The eggs of the check lots hatched almost perfectly. The dates on which the various submerged lots were taken from the water, and the writer's estimates of the percentages of eggs that hatched, were as follows: lot 1, April 2, 25 per cent.; lot 2, April 18, 20 per cent.; lot 3, April 23, 18 per cent.; lot 4, May 1, 25 per cent.; lot 5, May 5, 20 per cent.; lot 6, May 13, 20 per cent.; lot 7, May 24, 5 per cent. The submergence did not seem to kill the eggs as readily in these tests as in those reported last year. This may have been due to the unseasonable coldness of the spring this season, which probably caused the water in the pond to warm up more slowly than usual.

On May 29, 59 gypsy-moth caterpillars from one-eighth to five-sixteenths of an inch long were submerged on the leaves of an oak branch just as they were taken from the woods, in 8 inches of water in a washtub. All but 3 of the worms clung to the branch and went down into the water with it. At the end of a forty-three-hour submergence, 8 floated on the surface, 4 had sunk to the bottom of the tub, and 47 still clung to the leaves. These worms were watched for two days after the close of the test, but only 1 of the 59 showed any sign of life.

On May 31, 50 caterpillars from one-quarter to five-sixteenths of an inch long were submerged, as before, on the leaves of an oak branch in 9 inches of water. All these worms clung to the leaves tenaciously when submerged. After twenty-two hours in the water, 2 floated on the surface,

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[1] The Cranberry Rootworm, Bul. No. 263, U. S. Dept. Agr., 1915.

3 had sunk to the bottom, and 45 still clung to the leaves. They were then taken from the water, and within seven hours 26 had nearly or entirely recovered.

On June 1, 152 worms from one-quarter to three-eighths of an inch long were submerged on the leaves of an oak branch, as before, in 9 inches of water. After thirty-eight and one-half hours of submergence, 46 floated on the water, most of them being alive and active, 40 had sunk to the bottom, and 66 still clung to the leaves. Those clinging to the branch were then taken from the water and watched, and only a few ever showed any sign of recovery. As a rule, the worms that came to the surface of the water were among the largest of those submerged, as was also the case in later tests, descriptions of which are not included here.

The results of these experiments and of observations of bog flooding operations, in which the small gypsy caterpillars behaved similarly, have led the writer to the following conclusions: —

1. That reflowing for this insect will be most satisfactory if done while the worms are small and probably before the largest are more than five-sixteenths of an inch long. The sooner it is done after the eggs are all hatched the less will be the damage from the feeding of the worms and the less the trouble from their floating ashore alive, as it is evidently the habit of the very young caterpillars to cling to their support when submerged.

2. To be entirely effective, even when the worms are small, a flowage must probably be held nearly forty hours.

Mr. C. W. Minott of the Bureau of Entomology of the United States Department of Agriculture conducted some interesting investigations during May and June, 1916, concerning the wind-spread of gypsy-moth caterpillars on cranberry bogs. With his permission the following condensed account of these studies is given here: —

> Two bogs in Carver, Mass., were selected for experiments on wind dispersion, namely, Muddy Pond bog, containing about 100 acres, and John's Pond bog, containing about 44 acres (including pond). Six screens made of cotton cloth tacked to a frame in two sections, each being 3 by 10 feet, were set up horizontally just above the tops of the vines at various distances from the neighboring woodlands. Each screen contained 60 square feet of cloth upon which "tanglefoot" was applied. Daily examinations of each screen were made and data were taken concerning the temperature and the direction and velocity of the wind during the dispersion period.
>
> The screens were located on the bogs at various distances, ranging from 400 to 1,200 feet, from woodland infestations. From one screen, located 600 feet from infested woodland on the northwest and 900 feet on the west, 62 small caterpillars were removed during the season, or slightly more than 1 to the square foot. A total of 143 small worms was wind-borne on to the six screens, which indicated that an average of about 17,000 per acre blew on to the bogs. The infestations around these bogs are as yet only medium in extent, this showing what may be expected when the surroundings of bogs become thickly infested.[1]

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[1] Collins, C. W.: Methods used in determining Wind Dispersion of the Gipsy Moth and Some Other Insects, Journal of Economic Entomology, Vol. 10, p. 174, 1917.

The Cranberry Tip Worm (*Dasyneura vaccinii* Smith [1]).

The season's observations of the effect of resanding on the abundance of this pest sustained the conclusions heretofore reported.

One species of Chalcidid (*Tetrastichus* sp. [2]) and two of Proctotrypid (*Aphanogmus* sp. [3] and *Ceraphron* sp. [3]) parasites were reared from the larvæ of the last brood after they had encased themselves in their cocoons this season. Two of these (*Tetrastichus* sp. and *Aphanogmus* sp.) emerged in only small numbers, but the *Ceraphron* species had infested a large, though undetermined, majority of the maggots collected by the writer, and its adults kept coming out from August 9 to September 14, inclusive, their period of most rapid emergence being from August 12 to August 22.

The eggs of the tip worm are not "white" as they have been described.[4] They are watery translucent in appearance, with scattered pinkish pigment, and are about one-third of a millimeter long. They are elongate, usually slightly curved from end to end, with rounded and slightly narrowed ends and without noticeable surface markings.

The Black-Head Fireworm (*Rhopobota vacciniana* (Pack.)).

Prof. H. B. Scammell, in cranberry insect investigations in New Jersey for the Bureau of Entomology, had much success last year in treating both broods of this insect in the worm stage with a form of nicotine sulfate known as "Black-Leaf 40." He used 1 part of this insecticide to 400 parts water, and added resin fish-oil soap at the rate of 2 pounds to 50 gallons to make the spray spread and stick. When the writer saw the plots Professor Scammell had treated in this way, they were green and had a fair amount of fruit, whereas the surrounding bog, and even plots sprayed with arsenate of lead, had been turned brown by the insect and bore practically no crop.

The writer tried this treatment against the first brood on two large plots this season, and while it failed to control the insect entirely, it checked it so much that the plots remained green while the surrounding bog was turned rather brown, the contrast being striking.

This insecticide must be tested further before it can be said at what strength it should be used or how many times it should be applied to either brood. At the strength in which it has so far been tested it is a rather expensive treatment, costing about $7 per acre per application. It may be found, however, that weaker mixtures suffice. At any rate, this treatment stands at present as the only really effective method of controlling the first brood of this insect, burning and flooding excepted, and in spite of its expense it will, therefore, find favor in the management of many bogs. Two, and perhaps three, applications for the first brood are advisable.

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[1] Bul. No. 175 of the New York State Museum, p. 151.

[2] Determined by Mr. A. A. Girault of the Bureau of Entomology.

[3] Determined by Mr. J. C. Crawford of the Bureau of Entomology.

[4] Smith, J. B.: Insects Injurious in Cranberry Culture, Farmers' Bulletin No. 178, U. S. Dept. Agr., 1903, p. 19.

As a treatment for the second brood, it may have to compete with arsenate of lead, for there is danger of injuring tender foliage, and especially blossoms, in spraying with any contact insecticide, and arsenate of lead is far more effective with the second brood than with the first. Proper treatment of the first brood with "Black-Leaf 40" may check the pest so well that a thorough treatment of the second brood will not be so necessary as it is at present. In any case, not more than one application of "Black-Leaf 40" for the second brood is likely to be desirable.

The writer gave some cranberry uprights sprayed with "Black-Leaf 40" to some gypsy-moth caterpillars, providing another lot with unsprayed vines as a check. The latter were eaten much more freely than the former. This suggests that the effectiveness of this insecticide may be partly due to a deterrent property.

The second brood of the fireworm did less damage than usual this season, and less than might have been expected from the abundance of the first brood. The wet season seemed to check it strongly somehow.

The Cranberry Fruit Worm (*Mineola vaccinii* (Riley)).

This insect did the least injury this season of any year in the writer's experience. It has not been less prevalent since 1903. We have no reliable information concerning its abundance in years previous to 1904.

The writer has tried to determine, as far as possible, the relative abundance of this pest in the various cranberry-growing regions. It is most harmful on Cape Cod and in Wisconsin, being far less troublesome in New Jersey, the amount of injury on dry bogs (without winter-flowage) in the latter section, when the writer was there in 1915, being about the same as that on the flowed bogs of the Cape in the same season. It does about the same damage on Long Island and Nantucket as in New Jersey, being far less prevalent there than on Cape Cod. It appears to be almost if not entirely, unknown on the Pacific coast of Oregon and Washington.

It will be seen that *this insect is not usually very troublesome except in the regions with comparatively cold and dry climates, a heavier total precipitation as well as a higher average temperature being characteristic of the warmer sections. One might expect from this that any variation in the Cape Cod climate toward that of the warmer regions would be likely to tend to reduce the pest, whereas any variation in the opposite direction would be likely to tend to make it more abundant.*

Cape Cod Data appear to strongly substantiate this Conclusion. — The season of 1905 was the worst on record for fruit-worm injury. The Cape had a lower mean temperature in 1904 than in any subsequent year up to the present time, and in 1905 had a smaller total precipitation than in any year since, in spite of the fact that the rainfall in all the last five months of the year except October was heavy. Of the severity of the winters 1903–04 and 1904–05, the Annual Summary of the New England Section of the Climate and Crop Service of the Weather Bureau for 1905 (page 3) remarks as follows: —

February — the last of the winter months, with its remarkably low temperature record — completes one of the coldest winters of official record. At Boston the mean temperature for the three months, December, January and February, 1904–05, 24.8 degrees, is the lowest for the winter months since 1871, excepting 24.4 degrees in 1903–04, and 24.5 degrees in 1873–74. The winter for New England, as a whole, was the coldest since the establishment of the weather service of this section in 1884. The mean temperature was 17.9 degrees, and the next lowest is 18 degrees for the winter, 1903–04.

As far as the writer can determine, the greatest reductions in fruit-worm activity in recent years, aside from that of this season, occurred in 1906 and 1913. The records of the Weather Bureau show that the total precipitation of 1906 on the Cape was the greatest of any year since 1904, May, June and July being especially wet months. The winter of 1905–06 was mostly an open one. Both temperature and precipitation ran abnormally high throughout the greater part of the period beginning with October, 1912, and ending May 1, 1913, the winter being very open. As affecting the abundance of the pest in 1916, it should be noted that September, 1915, was a month of record high temperatures for its season, that the winter 1915–16 was mostly very open, and that the first half of this growing season was very wet throughout.

In the latter part of May the writer covered large numbers of fruit worms in their cocoons, in quart cans partly filled with moist sand, with different measured and uniform depths of sand ranging from three-sixteenths of an inch to a full inch, and made records of the subsequent emergence of the adult insects. Unfortunately, no check of worms not covered with any sand was kept for comparison, but, judging from the freedom with which the parasites and moths emerged through three-sixteenths, one-fourth, three-eighths, one-half, five-eighths, two-thirds and even three-fourths inch depths, it appears that resanding as commonly done does not much affect the abundance of either the fruit worm or its worm parasites. The full inch covering of sand seemed to smother most of the moths and parasites, though a few of both came out even from that depth.

The writer liberated a number of apparently female moths from a boat on a pond on July 25, and three of them were seen to fly to the shore, a measured distance of about 272 feet, in a single flight, a toy balloon being anchored in the pond at their point of departure to measure from, and the measuring being done with twine. This demonstration of this insect's powers of flight is of interest in connection with the speculation concerning the annual infestation of bogs from surrounding uplands and from neighboring bogs.

Fruit-worm eggs showed a range in Chalcidid (*Trichogramma minuta*) parasitism of from about 25 to 75 per cent. on dry bogs and from none to about 75 per cent. on those with winter-flowage this year. This parasite was not found at all on half the flowed bogs examined, more than a quarter of the eggs showing its presence on only 3 out of 30 such bogs. It appeared to be entirely absent on some flowed bogs on which it infested from 76 to 89 per cent. of the eggs in 1915. Its great reduction on the flowed bogs may have been due to the long period of wet weather in the first half of the growing season.

The Braconid (*Phanerotoma franklini*[1] Gahan) parasitism was found to range from 24 to about 55 per cent. on dry bogs (without winter-flowage) and from none to about 33 per cent. on flowed ones. On one bog which had the winter-flowage held until May 25, 24 per cent. of the fruit worms were infested with this parasite, and on another, bared of the winter water on May 14, 21 per cent. were infested, these figures indicating that moderately late holding of the flowage perhaps does not reduce this parasite in proportion to its host as seriously as was suggested by the writer in last year's report (page 40.) It should be stated in this connection that the percentages of *Phanerotoma* and *Pristomeridia* parasitism given in this and previous reports only show the amounts of these parasitisms among the worms at work in the berries when the examinations were made, and indicate the parasitism of the entire season only in a very rough way. It was discovered this year that the parasitized worms leave the berries somewhat sooner than the unparasitized ones, examinations made toward the end of the pest's period of activity showing greatly reduced percentages for the worm parasitism as compared with those made earlier. Worms from the same location on one bog showed percentages of *Phanerotoma* parasitism on different dates, as follows: September 3, 33.3 per cent.; September 6, 40 per cent.; September 13, 2.3 per cent. The percentages of *Pristomeridia* parasitism found in this same location were as follows: September 3, 5.5 per cent.; September 6, 6.6 per cent.; September 13, 0.

Pristomeridia agilis[2] was very scarce this year, the percentage of its parasitism being found to range from none to 5½ on flowed bogs and from 4½ to about 10 on strictly dry ones.

The examinations by which the percentages of *Phanerotoma* and *Pristomeridia* parasitism given in this and previous reports were determined were made by crushing fruit worms between glass slides in such a way as to expel their viscera through the anal opening, the parasite larva, when present, apparently always being ejected with them and being found easily with a good hand lens.

A number of eggs deposited at the same time by *Phanerotoma* females under observation in eggs laid by fruit-worm moths in confinement where they were secluded from parasites, and subsequently kept in closed bottles, were examined with a microscope successively at various times after deposition. None of these parasite eggs examined after either thirty-six or forty-two hours showed any sign of hatching. Two of three examined at the end of forty-six hours had hatched, but the larvæ showed no sign of life. After forty-nine hours all the eggs had hatched, and some of the larvæ moved their mouth parts considerably. The weather was cool during the entire period (July 29 and 30) in which this investigation was in progress, the maximum temperature in the sun at the station bog being 80° F. and the minimum bog temperature being 40°.

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[1] This parasite, called *Phanerotoma tibialis* in the writer's previous reports, has recently been described as new to science, and given the name here used, by Mr. A. B. Gahan of the Bureau of Entomology. *Cf.* Proc. U. S. Nat. Mus., Vol. 53, 1917, p. 200.

[2] The exact identity of the species is still in doubt.

Cocoons of parasitized fruit worms are usually much smaller and more delicate than those of unparasitized ones.

Submergence tests were conducted with fruit worms in their cocoons, as follows: —

1. Six small cheesecloth sacks, each containing 20 cocoons, were submerged to a depth of 2 feet in a pond at 10.30 A.M., September 14. They were all taken from the water and examined in the afternoon of September 26, and all the worms were found dead, a majority of them being partly decomposed. Most of them had left their cocoons and were on the inside of the sacks.

2. Three lots of cocoons of 20 each were submerged in cheesecloth sacks to a depth of 2 feet in a pond at 9 A.M., September 30. These were all taken from the water and examined between 11 A.M. and 1 P.M., October 12. All the worms were found dead, most of them being more or less decomposed. About half had left their cocoons and were clinging to the inside of the sacks.

3. Two cheesecloth sacks, each containing 20 cocoons, were submerged in 2 feet of water in a pond at 3 P.M., October 12. These sacks were taken out and examined at 5 P.M., October 24. Most of the worms were found dead and more or less decomposed, as in the previous tests, but 7 were alive in one sack and 2 in the other.

4. Two cheesecloth sacks, each containing 20 cocoons, were submerged to a depth of 2 feet in a pond at 8 A.M., October 25. They were taken out and examined on November 6, 17 being found alive in one sack and 8 in the other.

In all these tests the sacks were of the same material, were tied up and submerged in the same way, to the same depth in the same place and for practically the same length of time. It will be seen that as the season advanced the submergence had much less effect on the worms. As the pond grew colder fast while these tests were in progress their results suggested that the temperature of the water largely determined its effect.

At 1 P.M., Jan. 3, 1917, a weighted cheesecloth sack, containing 15 fruit worms in their cocoons, was placed in the bottom of each of two 1-quart cans full of water, the water being at a temperature of 59½° F., and the cans, with their covers on tight, were placed in a chicken incubator together with Green maximum and minimum registering thermometers, the incubator being set to run at a temperature of 60° F. As a check on these cans, two similar cans containing similar lots of fruit worms were placed in a pail of water at the same time, the temperature of the water in the cans and in the pail around them being about 35° F. The pail, together with maximum and minimum registering thermometers, was placed in a barrel the temperature of the air in which was about 37° F. The barrel was headed up and buried in hay to keep its contents at an even temperature. The cocoons in both the incubator and the barrel were taken from the water at 9 P.M., January 15, and were examined the next day in a warm room. All but 9 of the 30 worms that had been in the incubator were dead, whereas all but 3 of the 30 from the pail were alive. Those taken from the pail were as a rule very lively after they got warmed up, most of them crawling actively. On the other hand, none of those from the incubator became active, the live ones showing they were so only when prodded considerably, their movements even then being very sluggish. None of the dead worms had begun to decompose. The temperature of the incubator was shown by the thermometers to have ranged from 52° to 66° F. during the test. The temperature of the water in the cans kept in it was 57° F. at the end of the test, and had probably averaged a little under 60°. The temperature in the barrel had ranged from 31° to 39½° F., that of the water in the pail being 35° at the end of the test.

This incubator and pail experiment was duplicated by a test carried out similarly in all details, except that vaseline bottles of 3½-ounce capacity, with tightly inserted cork stoppers, were used instead of the cans, the cocoons being submerged at noon, Jan. 29, 1917, and being taken from the water at 3 P.M., February 13. Of the 30 worms kept in the incubator 16 were dead and 14 alive at the end of the test, while of the 30 tested in the pail 27 were alive and only 3 dead. Moreover, the live worms from the bottles in the pail were much more active after they got warmed up than were those from the incubator. None of the dead worms had begun to decompose noticeably. In this test the temperature in the barrel ranged from 32° to 36° F. The incubator got out of order twice, — on the seventh and tenth days of the test, — its temperature the first time falling to 40° and the second to 33° F. With these exceptions it ran between 52° and 62°, and probably averaged about 56°.

Many of the cocoons used in these tests were carefully opened under water at the end of the submergence, and, while they were all found to be largely filled with water, none were without a little air or gas, this indicating that the findings in this regard previously reported by the writer[1] were not quite accurate, the former examinations apparently not having been sufficiently careful.

The results of these experiments seem to prove that the effect of submergence of the worms in their cocoons depends largely, if not principally, upon the temperature of the water, and they suggest that a flowage after picking, if it is begun before October 1 and continued for twelve or possibly even ten days, may control this insect as well as late holding of the winter-flowage usually does. It may be said that such a flooding would interfere with harvesting, but as late picking is usually a result of late holding of the previous winter-flowage, and as late holding is most commonly practiced as a treatment for the fruit worm, this objection does not seem valid. Flooding practiced annually after picking would probably have a much less harmful effect on a bog than late holding of the winter-flowage every year has.

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[1] Bul. No. 160, Mass. Agr. Expt. Sta., 1915, p. 113.

Bog Management.

Prof. H. B. Scammell has recently reported [1] a destructive visitation of the fall army worm (*Laphygma frugiperda* S. & A.) this year on widely separated cranberry bogs in New Jersey following closely, and evidently somehow caused by, the removal of the winter-flowage in mid-July. This insect feeds on a variety of plants, but has not heretofore been known as a cranberry pest. As its frequent outbreaks, which start in the southern States, sometimes reach as far north as Canada, by the spreading of the successive broods of strong-flying moths, in a single season, though it is unable to endure the winter in the north, there is ground for fearing that midsummer removal of the winter-flowage may more or less regularly invite serious trouble from this insect on Cape Cod as well as in New Jersey. This unexpected development must be regarded as a possible complication in connection with certain phases of the biennial cropping system suggested by the writer in last year's report (page 46).

Late holding of a deep winter-flowage is sometimes dangerous. This flowage was started off from a bog in Assonet, Mass., on June 10, its withdrawal being completed on the 11th. When the writer visited this bog on June 30 the vines seemed completely dead where the flowage had been deepest (5 feet deep), whereas they showed no injury, aside from the retarded seasonal development of growth, where the water had been shallowest (2 feet deep), their leaves having been well retained and appearing green and healthy. Where the water had been deepest the leaves were all off, the buds at the tips of the uprights were gone, and the vines were brittle and showed no green in the break when broken off. There was a complete gradation from this condition to that where the flowage had been shallowest, corresponding with the variation in elevation.

Part of the vines on this bog were set out in the spring of 1914, and part in the spring of 1915, strips of both plantings running from the lowest to the highest parts of the bog. The writer is informed by the manager that the one-year sets where the flowage was deep finally recovered somewhat, but that the two-year plantings were killed entirely.

A large bog in Rochester, Mass., the winter-flowage of which ranged in depth from 4 feet to nothing, had this flowage held until May 31 this season. This is an old bog, with vines well established. Where the water was deepest the leaves all came off, leaving the uprights alive but bearing only the terminal bud. On the other hand, there was no abnormal falling of the leaves where the water was shallow. As on the Assonet bog, there was a complete gradation in the injury corresponding with the variation in the depth of the flowage.

A new 60-acre bog at Assonet, Mass., was flowed on the night of May 31, the vines being completely submerged for forty-eight hours, the water ranging from 3 feet to a few inches in depth, and averaging about 2½ feet.

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[1] Proc. 47th Ann. Meet. of the Amer. Cranb. Grow. Assoc. p. 11, January, 1917.

The flooding and draining were done entirely at night. A few days later the writer's attention was called to an injury that had resulted. He visited the bog and found the buds and even the tops of the new growth of the uprights on parts of it seriously hurt. The injury was mainly on the central portion of the bog, and centered around a large pile of ashes left from the burning of stumps and brush when it was built. Vines at considerable distances from this pile showed at most but slight injury, except in a streak parallel to the end of the dike toward which the wind had blown during the flooding. Leaves of bushes which had hung down into or stood in the water of the reflow, around the margin of the bog, showed a marked and unusual burning injury, and they bore traces of a white powder which appeared to be ash that had floated in the water from the pile at the center of the bog. The situation as a whole led all those who observed it to conclude that the ash pile had caused the trouble. The pile was estimated to be 2½ feet deep over an area 25 feet square and about 6 inches deep over another area 75 feet square. Piles of ashes on bogs are probably dangerous because of the lye leached from them. Many unaccountable spots where vines refuse to grow thriftily on bogs may be the result of effects remaining from ashes left from the burning of brush piles. It is well known that alkalies in the soil are inimical to cranberry growth.

A portable sectional bridge devised by the writer for use in carting berries across bog ditches proved valuable at the station bog this year. With its help it was easy to cart berries without killing the vines in tracks by repeated passages of the wheels over the same ground. A light truck probably could be used to great advantage with this bridge, though the writer has tried only a horse and wagon with it so far. At any rate, it will make it possible to much reduce the present expense of removing berries from bogs. It may be seen at the station bog at any time during the cranberry season.

With many Cape Cod bogs a desirable reduction in the cost of resanding could probably be effected by the development of a sanding rim around the margin. With such a rim the sand for any part of the bog could always be brought from the nearest point. The rim should be wide enough for a good roadway, and it should be built level with the bog surface, so that it may serve as a sanitary catch-basin for floating berries and leaves. If, as the results of some of the writer's storage experiments seem to indicate, the berries from the marginal portion of a bog, other conditions being the same, are usually of poorer keeping quality than those from the center, the condition may naturally be laid to the continual deposition of diseased cranberry material floating on the surface of repeated flowages and wafted to the margin by the wind. Thus the possible value of a marginal catch-basin as suggested becomes evident. The sanding rim would also have some value as fire protection for a bog.

As the sanding rim becomes sufficiently widened by the removal of sand in repeated resandings, the bog can be gradually enlarged by planting on the inner side of the rim, this increase in property being mostly clear gain.

The sanding rim can be constructed most advantageously when a bog is built. Its development after the bog is planted is attended with some difficulties. Among these the extra cost of turfing the upland adjacent to the bog, and the liability in resanding of seeding the bog more or less with certain troublesome weeds, should be especially considered.

OBSERVATIONS ON THE SPOILAGE OF CRANBERRIES DUE TO LACK OF PROPER VENTILATION.

BY C. L. SHEAR AND NEIL E. STEVENS, PATHOLOGISTS, AND B. A. RUDOLPH, SCIENTIFIC ASSISTANT, FRUIT-DISEASE INVESTIGATIONS, BUREAU OF PLANT INDUSTRY.

INTRODUCTION.

The injury to cranberries due to keeping them in tightly closed packages was brought strikingly to the writers' attention during temperature tests conducted in the fall of 1916. Uniform samples of Early Black cranberries from bogs near Wareham, Mass., were put up in pound coffee cans and sent to Washington by mail. There they were placed in the constant temperature apparatus used by Drs. Brooks and Cooley of this office, and described by them in their recent paper.[1]

One can from each lot was placed at each of the following temperatures: Centigrade, 0, 5, 10, 15 and 20 degrees (equal to 32, 41, 50, 59 and 68 degrees Fahrenheit). They were kept at these temperatures from early in September until about the middle of November. When the berries were removed from the cans and sorted, it was found that spoilage at the lower temperatures had been much greater than the previous experience of the writers had led them to believe could be due to fungi alone. Many of the spoiled berries had a peculiar lusterless appearance, and were of a uniform dull red color differing both from normal and from typical rotten berries.

Among various factors considered as possible causes of this condition the excessive accumulation of carbon dioxide seemed the most probable. The work of F. W. Morse,[2] Gore [3] and others has proven that large amounts of this gas are given off in the respiration of various fruits, while the studies of Fulton [4] indicate that the spoiling of strawberries and raspberries which he noted in tight packages is due to the accumulation of carbon dioxide. Fulton found that if strawberries were kept in tightly closed bottles for three days the oxygen of the air was practically exhausted, and more than 35 per cent. by volume of carbon dioxide had accumulated. Under these conditions, as well as in cartons tightly wrapped, "The fruit softened and had the characteristic bad flavor of fruit confined in an atmosphere of carbon dioxide" (3, p. 22).

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[1] Brooks, Charles, and Cooley, J. S.: Temperature Relations of Apple-rot Fungi. Journal of Agricultural Research, 8, 139–163, 1917.

[2] Morse, Fred W.: Effect of Temperature on the Respiration of Apples. Jour. Amer. Chem. Soc., 30, 876–881, 1908.

[3] Gore, H. C.: Studies on Fruit Respiration, U. S. Dept. Agr., Bur. of Chem., Bul. No. 142, 1911.

[4] Fulton, S. H.: The Cold Storage of Small Fruits, U. S. Dept. Agr., Bur. of Plant Indus., Bul. No. 108, 1907.

Dr. Charles Brooks and Dr. E. M. Harvey of this office, who have separately studied storage conditions in apples and other fruits, examined the cranberries referred to and were of the opinion that the condition might very likely be due to the accumulation of an excessive amount of carbon dioxide. Although it was then too late in the season (November 20) to undertake a thorough investigation of the subject, preliminary tests were made which gave results of considerable interest.

Temperature Tests in Open and Closed Cans.

In order to compare directly the keeping of cranberries in open and closed cans, uniform lots of sound berries were divided, one portion being placed in tightly closed cans, and the other portion in similar cans with the covers removed. The result of one of these tests, which is typical of several, is given in the following tables: —

Temperature Tests on Howes from State Bog, Massachusetts, beginning November 21, ending December 16.

Closed Cans.

Temperature in Degrees C.	Sound.	Spoiled.	Spoiled (Per Cent.).
20,	328	172	34.5
15,	357	147	29.5
10,	444	67	13.0
5,	472	29	5.5
0,	483	20	4.0

Open Cans.

20,	291	69	19.0
15,	333	61	15.5
10,	333	29	8.0
5,	341	18	5.0
0,	340	8	2.5

It will be noted that in all cases the amount of spoilage is greater in the closed cans than in the open cans.

EFFECT OF CARBON DIOXIDE ON CRANBERRIES.

Several series of tests were made in which cranberries from various sources (Early Blacks and Howes from Massachusetts, and Howes from New Jersey) were kept for short periods in an atmosphere of nearly pure carbon dioxide. It was noticed in each case that at the end of three days practically all the berries in the carbon dioxide were spoiled, whereas berries from the same lots kept in similar containers with air showed very little rot even at the end of two weeks.

The berries which had been kept in an atmosphere of carbon dioxide had the peculiar uniform dull, lusterless, red color which had been noticed in many of the berries which had spoiled in closed cans. On sectioning these berries it was found that the tissue of the berry, which is white in a normal berry, had taken on the same uniform red color. Berries which have been treated in this manner have a peculiar, bitter taste, which is very characteristic. They are no longer firm, as in the sound fruit, nor elastic to the touch as in rotten fruit, but have become flaccid. The same effect on the berries was readily produced by sealing up a quantity in an air-tight container, and allowing them to remain at room temperature for a week.

That this injurious effect is produced by the accumulation of carbon dioxide is indicated by preliminary tests made in December, 1916. Equal quantities of sound Early Blacks or Howes were put in similar containers (Hempel desiccators). One of these desiccators was filled with carbon dioxide, the other two contained air, but the upper portion of one of them was filled with a saturated solution of potassium hydroxide, which would absorb the carbon dioxide almost as fast as given off by the berries. The berries in the first lot were thus exposed to an atmosphere of carbon dioxide throughout the test; those in the second lot were exposed to air containing practically no carbon dioxide; and those in the third to an atmosphere in which the carbon dioxide given off in respiration was allowed to accumulate. The results of one of these tests which was typical of all are given in the following table: —

CONDITIONS UNDER WHICH BERRIES WERE KEPT.	CONDITION OF BERRIES AT END OF TEST.		
	Sound.	Spoiled.	Spoiled (Per Cent.).
CO_2,	35	34	50
Air exposed to water,	56	39	40
Air exposed to KOH solution,	45	19	29

It will be noted that the amount of spoilage, including rot due to fungi, is greatest in the berries exposed to carbon dioxide and least in the container from which this gas was removed, which apparently indicates that a large portion of the spoilage was due to the carbon dioxide.

EFFECT OF DIFFERENT RELATIVE HUMIDITIES ON SPOILAGE DUE TO CARBON DIOXIDE.

Most of the tests described above had been made in atmospheres having relatively high moisture content. In order to determine whether the humidity of the air in any way influenced the spoilage, a series of tests was run in which sound cranberries of the Howes variety were kept in tightly sealed Hempel desiccators which were maintained at constant humidity by sulfuric acid solutions of different densities. This method has been described by one of the writers in an earlier paper.[1] All these tests were made at a temperature of about 24° C.

Chambers having relative humidities of 100 per cent. (saturated atmosphere), 75 per cent., 50 per cent., 25 per cent. and approximately 0 per cent. were used, and so far as could be detected by careful observation there was no difference in the rate of spoilage at the different humidities.

RELATION OF FUNGI TO SPOILAGE DUE TO CARBON DIOXIDE.

It is of course possible that one effect of accumulation of carbon diox at least in small amounts, may be to make the berries more susceptible to the attacks of fungi. It seems certain, however, that the injury to the fruit is in many cases wholly independent of the action of fungi.

On March 13, 1917, we received from Dr. Franklin a box of Pride cranberries taken from a crate of fruit which had been kept in storage in the basement of the screenhouse at the State experimental bog at East Wareham. These were taken to represent the average condition of the spoiled fruit at the time. This lot contained 271 berries. They were carefully sorted, and 195 were somewhat softened and flaccid, having much less resiliency than the rotten fruit, in which the tissues are more or less destroyed by the growth of fungi. They had the same general appearance as berries treated with carbon dioxide, and their condition was believed to be due to the time and manner in which they had been kept rather than to fungous disease. Fifty of these berries were taken at random and cultures made by transplanting the bulk of the pulp from the cranberries, the skin being removed. Of these cultures, but 2, or 4 per cent., produced fungi. Assuming that this represents the average number affected with fungous disease, deducting 4 per cent. from the total, 195, would leave 187 presumably free from fungous disease. Cultures were also made from the tissue of the remaining 76, which had more the appearance and character of fruit attacked by fungi. The results of these cultures showed, however, that 49 of these berries were apparently destroyed by some other cause than fungous disease, thus making a total of 236 out of 271, or 87 per cent., not destroyed by fungi but presumably by the period and conditions of storage since picking.

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[1] Stevens, Neil E.: A Method for studying the Humidity Relations of Fungi in Culture. Phytopathology, 6, 428-432, 1916.

From a sample of cranberries of the cherry variety taken July 2, 1917, at Madrid, Me., which had been kept in the cellar of a house all winter, 50 softened berries were chosen at random and cultures were made from their pulp, as described above. Twenty of these berries, or 40 per cent., yielded the end-rot fungus, while 22 berries, or 44 per cent., showed no fungi, and were presumably destroyed by the other causes discussed in this paper.

Effect of Carbon Dioxide on Fungi in the Berries.

That carbon dioxide in high concentrations injures fungi in the cranberries as well as the berries themselves is indicated by a test in which equal numbers of rotten cranberries from a single lot were placed in similar vessels, one of which was filled with carbon dioxide and the other left open. At the end of one week transfers of tissue were made from each berry. Of the berries which had been kept in an atmosphere of carbon dioxide 70 per cent. contained no viable fungi and the others yielded *Penicillium*, or the end-rot fungus. Of the berries kept in the open vessel only 15 per cent. contained no living fungi, and the others yielded fungi of six different species.

The rate at which carbon dioxide is given off by cranberries in storage and the variation of this rate with temperature, the concentration of the gas necessary to cause injury, and the concentration which occurs under storage conditions, have not been determined, and further investigations on this line are planned. It seems very probable from the facts now in hand, however, that this spoilage is a considerable factor in the loss during storage, and throws new light on the results of Dr. Franklin, [1] which indicate the importance of ventilation, as well as on this year's results in shipping cranberries in tight as compared with ventilated packages.

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[1] Franklin, H. J.: Report of Cranberry Substation for 1915, Mass. Agr. Expt. Sta., Bul. No. 168, 1916.

BULLETIN No. 181.

DEPARTMENT OF CHEMISTRY.

DIGESTION EXPERIMENTS WITH SHEEP.

J. B. LINDSEY, C. L. BEALS AND P. H. SMITH.[1]

INTRODUCTION.

The digestion experiments reported in this bulletin were made during a number of years, beginning with the autumn of 1912. They include portions of Series XVIII. and XIX. and all of Series XX., XXI. and XXII., with the exception of one experiment in Series XXII. Each series includes a period of time between the early autumn and the following spring. A few of the results have been given in other publications.

The basal ration in the majority of cases was English hay, or English hay and gluten feed.

The usual method of conducting the tests was employed, and has been fully described elsewhere.[2]

The composition of the feeds tested in the several series is presented in the tabulation known as Table I., which is arranged alphabetically.

Table II. is arranged by series, beginning with Series XVIII. It contains the average amount of feces excreted daily by each sheep, the weight of one-tenth of the feces in air-dry condition, the percentage of dry matter in the air-dry feces, and the composition of the dry matter.

Table III. contains the weight of the animals at the beginning and end of each digestion period, and the average amount of water consumed daily.

In Table IV. will be found the digestion coefficients of *basal rations* used in the computations which follow in Table V. This table, headed "Computation of Digestion Coefficients," presents the detailed data of each trial, together with the resulting coefficients. Following the complete data will be found a summary of the coefficients secured for each material, together with a discussion of the results.

Table VI. gives an average of the coefficients secured for each feed tested.

It may be stated that the period in nearly all cases extended over fourteen days, the first seven of which were preliminary, the collecting of the feces being made on the last seven. Ten grams of salt were fed each sheep daily, and water *ad libitum*. The sheep were grade Shropshires, as nearly as possible of the same age and weight.

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[1] Mr. Smith and Mr. Beals did the larger part of the analytical work and the tabulations; the work at the feeding barn was carried out by Mr. J. R. Alcock.

[2] Eleventh report of the Mass. State Agri. Exp. Sta., pp. 146–149 (1893).

TABLE I. — COMPOSITION OF FEEDSTUFFS (PER CENT.) (ARRANGED ALPHABETICALLY).

Series.	Period.	Feeds.	Dry Matter as weighed out.	Dry Matter Basis.				
				Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XXII.	12	Alfalfa (third cutting, fine quality),	87.62	6.03	15.11	35.42	41.53	1.91
XXII.	14	Alfalfa (third cutting, fine quality),	91.25	6.95	15.57	34.70	40.72	2.06
XVIII.	4	Cabbage (heads),	9.66	8.22	17.98	9.84	62.77	1.19
XVIII.	5	Cabbage (leaves),	19.05	14.49	11.94	13.12	58.04	2.41
XIX.	7	Cabbage (whole),	11.73	12.20	21.82	10.30	53.76	1.92
XIX.	8	Carrots,	12.54	8.56	8.00	8.25	74.04	1.15
XX.	8	Carrots,	13.13	10.31	11.23	8.83	68.61	1.02
XX.	9	Carrots,	11.40	9.81	11.11	8.50	69.49	1.09
XIX.	13	Corn bran,	90.42	.86	5.22	14.50	78.15	1.27
XXI.	7	Corn bran,	90.24	1.30	8.52	13.21	74.52	2.45
XIX.	12	Distillers' grains (corn),	93.86	1.83	29.45	12.62	46.20	9.90
XXI.	6	Distillers' grains (corn),	96.87	2.31	26.40	14.71	47.18	9.40
XXI.	12	Feterita,	89.59	1.80	13.23	1.40	80.23	3.34
XIX.	2	Gluten feed,	89.55	1.05	27.84	8.75	57.78	4.58
XIX.	5	Gluten feed,	89.93	1.11	26.96	8.70	59.29	3.94
XIX.	14	Gluten feed,	90.52	.95	27.93	9.32	56.86	4.94
XIX.	15	Gluten feed,	90.87	2.30	25.84	8.17	58.95	4.74

XX.	3	Gluten feed,	91.10	1.84	25.55	8.27	59.69	4.65
XX.	4	Gluten feed,	91.72	2.03	25.85	8.26	59.22	4.64
XX.	5	Gluten feed,	91.14	1.95	26.73	8.33	58.39	4.60
XX.	9	Gluten feed,	91.35	2.21	26.57	7.76	58.65	4.81
XX.	11	Gluten feed,	91.45	2.16	25.47	8.37	59.38	4.62
XX.	13	Gluten feed,	91.80	2.15	25.84	8.21	59.35	4.45
XX.	14	Gluten feed,	92.09	2.13	27.11	8.55	57.72	4.49
XXI.	1	Gluten feed,	90.32	3.36	28.29	7.43	59.11	1.81
XXI.	3	Gluten feed,	90.44	3.49	28.05	7.30	59.37	1.79
XXI.	8	Gluten feed,	91.05	3.42	27.86	7.30	59.69	1.73
XXI.	11	Gluten feed,	91.54	3.37	28.09	7.65	59.06	1.83
XXI.	12	Gluten feed,	91.50	3.41	27.94	7.39	59.70	1.56
XIX.	10	Gluten meal (Diamond),	94.40	.86	44.99	2.16	50.18	1.81
XIX.	11	Gluten meal (Diamond),	93.80	1.14	44.79	1.84	50.21	2.02
XIX.	12	Gluten meal (Diamond),	94.01	1.34	44.99	2.01	49.73	1.93
XXI.	5	Gluten meal (Diamond),	90.97	1.13	45.14	2.06	49.97	1.70
XXI.	6	Gluten meal (Diamond),	91.06	1.16	45.12	2.23	49.62	1.87
XXI.	7	Gluten meal (Diamond),	91.55	.96	44.58	2.02	50.79	1.65
XVIII.	3	Hay (English),	86.75	5.67	9.87	31.56	50.21	2.69
XVIII.	4	Hay (English),	89.35	5.26	9.25	31.33	51.50	2.66
XVIII.	5	Hay (English),	88.80	5.72	9.47	31.48	50.42	2.91
XVIII.	6	Hay (English),	88.92	6.53	9.39	32.35	49.11	2.62

TABLE I. — COMPOSITION OF FEEDSTUFFS (PER CENT.) (ARRANGED ALPHABETICALLY) — *Continued.*

Series.	Period.	FEEDS.	Dry Matter as weighed out.	DRY MATTER BASIS.				
				Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XVIII.	7	Hay (English), ...	89.07	6.49	9.32	31.27	50.25	2.67
XIX.	2	Hay (English), ...	88.02	5.83	9.52	31.40	50.98	2.27
XIX.	3	Hay (English), ...	87.00	5.86	9.45	30.94	51.51	2.24
XIX.	4	Hay (English), ...	87.47	5.91	9.42	31.48	50.77	2.42
XIX.	5	Hay (English), ...	88.05	5.81	9.43	31.70	50.78	2.28
XIX.	6	Hay (English), ...	87.87	5.55	9.00	31.34	51.42	2.69
XIX.	7	Hay (English), ...	88.57	5.56	8.15	31.83	52.04	2.42
XIX.	8	Hay (English), ...	88.75	5.73	8.13	34.66	49.22	2.26
XIX.	9	Hay (English), ...	88.75	5.74	8.52	31.22	51.20	3.32
XIX.	10	Hay (English), ...	90.27	5.76	7.57	32.07	52.27	2.33
XIX.	11	Hay (English), ...	92.35	5.66	7.02	32.07	52.89	2.36
XIX.	12	Hay (English), ...	89.75	6.05	7.36	32.06	51.53	3.00
XIX.	13	Hay (English), ...	90.87	6.13	7.02	32.83	51.78	2.24
XIX.	14	Hay (English), ...	89.95	6.01	8.29	31.55	51.47	2.68
XIX.	15	Hay (English), ...	90.42	5.72	7.53	31.48	53.07	2.20
XX.	1	Hay (English), ...	92.17	6.01	7.22	32.43	51.80	2.54
XX.	2	Hay (English), ...	89.90	6.22	6.82	32.28	51.53	3.15

XX.	3	Hay (English), ...	90.00	6.09	7.32	32.14	51.91	2.54
XX.	4	Hay (English), ...	90.55	6.09	7.35	32.43	51.16	2.97
XX.	5	Hay (English), ...	90.52	6.01	8.68	31.98	50.54	2.79
XX.	6	Hay (English), ...	89.73	6.16	7.44	32.08	51.96	2.36
XX.	7	Hay (English), ...	91.92	6.09	7.33	32.69	51.54	2.35
XX.	8	Hay (English), ...	89.79	6.72	7.94	32.53	50.23	2.58
XX.	9	Hay (English), ...	90.37	6.23	7.60	30.44	53.06	2.67
XX.	10	Hay (English), ...	91.00	6.53	8.15	32.02	50.80	2.50
XX.	11	Hay (English), ...	91.07	6.80	8.57	32.14	49.99	2.50
XX.	12	Hay (English), ...	92.45	6.67	7.17	31.32	52.10	2.74
XX.	13	Hay (English), ...	92.02	6.40	7.30	32.22	51.61	2.47
XX.	14	Hay (English), ...	92.62	6.27	6.95	32.44	51.75	2.59
XXI.	1	Hay (English), ...	89.35	6.91	7.55	32.06	50.65	2.83
XXI.	2	Hay (English), ...	89.12	6.74	7.59	32.26	50.54	2.87
XXI.	3	Hay (English), ...	88.40	6.68	7.51	32.54	50.40	2.87
XXI.	4	Hay (English), ...	88.85	6.59	7.59	32.67	50.29	2.86
XXI.	5	Hay (English), ...	89.87	6.87	7.43	33.77	49.31	2.62
XXI.	6	Hay (English), ...	89.75	6.65	7.47	33.21	50.26	2.41
XXI.	7	Hay (English), ...	90.47	6.78	7.09	32.13	51.60	2.40
XXI.	8	Hay (English), ...	90.52	6.96	7.27	33.73	49.41	2.63
XXI.	9	Hay (English), ...	88.90	7.06	7.49	32.37	50.41	2.67
XXI.	10	Hay (English), ...	89.37	6.93	7.31	32.91	50.24	2.61

TABLE I. — COMPOSITION OF FEEDSTUFFS (PER CENT.) (ARRANGED ALPHABETICALLY) — *Continued.*

Series.	Period.	FEEDS.	Dry Matter as weighed out.	Dry Matter Basis.				
				Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XXI.	11	Hay (English), ...	90.80	8.54	10.20	30.49	48.06	2.71
XXI.	12	Hay (English), ...	90.17	8.46	9.65	30.57	48.59	2.73
XXI.	13	Hay (English), ...	90.65	8.27	9.12	31.06	48.83	2.72
XXI.	14	Hay (English), ...	88.43	8.10	9.03	31.24	48.89	2.74
XXII.	1	Hay (English), ...	86.70	7.71	9.17	30.29	50.30	2.53
XXII.	2	Hay (English), ...	85.67	7.59	8.65	31.93	49.28	2.55
XXII.	3	Hay (English), ...	88.25	8.06	9.47	30.45	49.47	2.55
XXII.	5	Hay (English), ...	89.00	7.55	9.43	31.12	49.66	2.24
XXII.	8	Hay (English), ...	89.92	6.85	8.25	32.89	49.66	2.35
XXII.	9	Hay (English), ...	90.13	7.18	8.37	33.80	48.25	2.40
XXII.	10	Hay (English), ...	90.00	7.32	8.70	32.16	49.36	2.46
XXII.	11	Hay (English), ...	90.75	6.75	8.23	32.97	49.58	2.47
XXII.	13	Hay (English), ...	90.87	7.19	8.14	33.26	49.02	2.39
XXII.	16	Hay (English), ...	89.87	7.21	9.06	30.33	50.64	2.76
XXII.	17	Hay (English), ...	88.07	7.01	8.74	33.39	48.05	2.81
XVIII.	3	Mangels, ...	16.43	5.93	5.26	5.96	82.57	.28
XVIII.	6	Mangels, ...	17.38	6.28	6.42	6.81	80.23	.26

XX.	11	New Bedford pig meal,	91.20	19.65	23.59	9.15	44.30	3.31
XXI.	8	New Bedford garbage tankage,	91.47	15.72	22.02	9.67	50.92	1.67
XIX.	4	Pumpkins (seeds removed),	5.42	8.81	13.74	17.33	57.56	2.56
XIX.	6	Pumpkins (entire),	8.81	7.60	17.72	16.86	43.14	14.68
XX.	2	Pumpkins (entire),	13.42	7.80	14.17	13.01	54.26	10.76
XX.	3	Pumpkins (entire),	15.92	7.26	15.67	14.39	51.77	10.91
XX.	4	Pumpkins (entire),	11.72	8.31	14.85	15.73	48.31	12.80
XXII.	15	Rowen,	90.87	8.12	13.03	28.15	47.29	3.41
XX.	7	Soy bean hay,	88.27	6.63	15.86	34.88	40.56	2.07
XIX.	10	Starch (potato),	90.58	–	–	–	100.00	–
XIX.	11	Starch (potato),	90.24	–	–	–	100.00	–
XIX.	12	Starch (potato),	90.79	–	–	–	100.00	–
XXI.	5	Starch (potato),	89.56	–	–	–	100.00	–
XXI.	6	Starch (potato),	90.27	–	–	–	100.00	–
XXI.	7	Starch (potato),	87.82	–	–	–	100.00	–
XXII.	11	Stevens' "44" Dairy Ration,	91.06	4.17	26.95	12.88	49.56	6.44
XXII.	1	Sudan grass (green),	23.50	6.50	11.78	27.87	50.71	3.14
XXII.	3	Sudan grass (dry),	78.12	8.59	13.57	33.28	42.93	1.63
XXII.	4	Sudan grass (dry),	88.00	7.37	11.89	35.79	43.51	1.44
XXII.	6	Sudan grass (dry),	88.07	9.67	15.49	33.32	39.99	1.53
XXII.	7	Sudan grass (dry),	87.92	10.07	14.45	33.20	40.74	1.54
XXII.	17	Sudan grass (green),	19.58	7.18	14.23	30.33	43.55	4.71

Table I. — Composition of Feedstuffs (Per Cent.) (arranged alphabetically) — *Concluded.*

Series.	Period.	Feeds.	Dry Matter as weighed out.	Dry Matter Basis.				
				Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XXI.	14	Sweet clover,	16.55	9.56	17.33	33.80	36.45	2.86
XXII.	16	Sweet clover,	14.50	4.60	21.46	26.78	43.76	3.40
XVIII.	7	Turnips (Swedish),	13.79	7.33	9.58	10.99	71.31	.79
XX.	12	Wheat gluten (high grade) flour,	91.66	.86	92.41	.11	6.23	.39
XXI.	4	Wheat gluten (high grade) flour,	92.96	.77	92.84	.07	5.91	.41
XXI.	10	Wheat gluten (high grade) flour,	94.96	.88	89.19	.09	8.18	1.66
XIX.	5	Vegetable ivory meal,	87.36	1.37	6.02	7.02	84.90	.69
XX.	13	Vegetable ivory meal,	91.25	1.19	4.72	8.27	85.05	.77
XXI.	3	Vegetable ivory meal,	89.10	1.19	5.33	8.75	83.17	1.56
XXII.	9	Vinegar grains (Fleischmann's),	92.22	2.51	20.56	20.13	50.32	6.48
XXII.	10	Vinegar grains (Fleischmann's),	92.53	2.57	20.22	20.12	50.34	6.75

TABLE II. — COMPOSITION OF FECES (PER CENT.).

Series.	Period.	Sheep.	FEEDS.	Average Daily Feces (Grams).	One-tenth Feces Air-dry (Grams).	Dry Matter in Air-dry Feces.	DRY MATTER BASIS.				
							Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XVIII.	3	V.	English hay and mangels,	371	15.994	94.67	15.84	12.59	23.56	43.20	4.81
XVIII.	3	VI.	English hay and mangels,	339	15.550	94.67	14.76	12.13	24.20	43.81	5.10
XVIII.	4	I.	English hay and cabbage (heads),	286	13.190	95.03	12.32	13.63	23.79	46.01	4.25
XVIII.	4	II.	English hay and cabbage (heads),	274	13.819	95.20	12.37	12.65	25.56	45.07	4.35
XVIII.	5	I.	English hay and cabbage (leaves),	377	18.623	95.19	18.05	12.53	22.20	42.78	4.44
XVIII.	5	II.	English hay and cabbage (leaves),	414	19.950	95.10	17.11	12.54	21.51	44.23	4.61
XVIII.	6	V.	English hay and mangels,	388	17.945	94.78	14.15	12.97	23.63	43.63	5.62
XVIII.	6	VI.	English hay and mangels,	364	17.344	94.87	13.31	11.62	24.98	44.68	5.41
XVIII.	7	V.	English hay and turnips (Swedish),	331	15.648	95.29	13.18	12.00	26.59	44.29	3.94
XVIII.	7	VI.	English hay and turnips (Swedish),	310	15.575	95.40	13.69	10.51	28.74	43.32	3.74
XIX.	2	V.	English hay and gluten feed,	470	22.650	92.47	9.25	12.79	27.62	46.75	3.59
XIX.	2	VI.	English hay and gluten feed,	465	22.300	92.59	10.47	12.62	26.49	46.81	3.61
XIX.	3	I.	English hay,	691	29.619	94.53	11.57	11.96	27.04	46.00	3.43
XIX.	3	II.	English hay,	653	31.510	93.55	10.53	10.46	30.00	45.74	3.27
XIX.	4	I.	English hay and pumpkins (seeds removed),	362	18.047	93.81	11.62	12.58	26.74	45.21	3.85
XIX.	4	II.	English hay and pumpkins (seeds removed),	380	19.805	93.91	12.92	11.34	28.62	43.35	3.77

TABLE II. — COMPOSITION OF FECES (PER CENT.) — *Continued.*

Series.	Period.	Sheep.	FEEDS.	Average Daily Feces (Grams).	One-tenth Feces Air-dry (Grams).	Dry Matter in Air-dry Feces.	DRY MATTER BASIS.				
							Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XIX.	5	V.	English hay, gluten feed and vegetable ivory meal,	589	25.210	94.30	9.16	15.60	25.96	45.32	3.96
XIX.	5	VI.	English hay, gluten feed and vegetable ivory meal,	598	24.191	94.50	9.80	14.70	25.34	46.72	3.44
XIX.	6	I.	English hay and pumpkins (entire),	554	25.333	95.00	10.65	12.68	28.88	44.04	3.75
XIX.	6	II.	English hay and pumpkins (entire),	456	22.869	94.87	11.87	12.60	28.40	43.04	4.09
XIX.	7	I.	English hay and cabbage (whole),	415	19.277	95.14	14.45	12.12	25.28	44.32	3.83
XIX.	7	II.	English hay and cabbage (whole),	386	20.009	94.93	14.62	11.04	28.18	42.41	3.75
XIX.	8	I.	English hay and carrots,	503	21.146	95.74	15.09	12.30	26.42	42.90	3.29
XIX.	8	II.	English hay and carrots,	411	19.484	95.87	15.24	11.25	26.75	43.33	3.43
XIX.	9	V.	English hay,	688	29.467	95.01	9.68	10.04	29.04	47.66	3.58
XIX.	9	VI.	English hay,	674	31.710	95.10	9.08	9.81	30.39	47.20	3.52
XIX.	10	III.	English hay, potato starch and gluten meal,	268	13.241	95.92	8.57	13.15	28.26	45.87	4.15
XIX.	10	IV.	English hay, potato starch and gluten meal,	328	14.744	95.81	10.08	12.92	28.06	45.12	3.82
XIX.	11	IV.	English hay, potato starch and gluten meal,	408	17.432	95.71	8.81	11.75	28.39	47.53	3.52
XIX.	12	IV.	English hay, potato starch, gluten meal and distillers' grains,	627	24.066	95.33	8.87	13.60	28.61	45.36	3.56
XIX.	13	I.	English hay and corn bran,	451	19.102	94.45	7.97	11.54	25.16	51.97	3.36
XIX.	13	II.	English hay and corn bran,	485	23.441	94.50	7.47	11.16	27.33	50.75	3.27
XIX.	14	V.	English hay and gluten feed,	539	23.730	94.06	9.17	13.01	26.06	47.47	4.29

XIX.	14	VI.	English hay and gluten feed,	566	26.221	94.22	8.70	11.00	28.28	47.97	4.05
XIX.	15	V.	English hay and gluten feed,	543	24.694	94.56	8.94	11.28	27.99	48.20	3.59
XIX.	15	VI.	English hay and gluten feed,	737	28.006	94.60	8.21	11.20	29.08	47.93	3.58
XX.	1	I.	English hay,	598	28.127	92.55	10.27	10.05	27.18	48.47	3.76
XX.	1	II.	English hay,	620	29.139	92.54	10.36	9.80	28.09	48.07	3.68
XX.	2	I.	English hay and pumpkins (entire),	486	22.314	94.62	11.09	12.80	27.06	44.09	4.96
XX.	2	II.	English hay and pumpkins (entire),	490	20.370	94.95	12.97	12.34	26.22	43.43	5.04
XX.	3	I.	English hay, gluten feed and pumpkins (entire),	577	24.890	94.94	10.84	12.91	26.26	45.85	4.14
XX.	3	II.	English hay, gluten feed and pumpkins (entire),	685	25.564	94.97	11.61	12.70	25.74	45.63	4.32
XX.	4	I.	English hay, gluten feed and pumpkins (entire),	486	21.687	94.42	10.07	13.77	28.78	43.36	4.02
XX.	4	II.	English hay, gluten feed and pumpkins (entire),	684	24.688	95.02	9.72	12.82	29.32	43.70	4.44
XX.	5	I.	English hay and gluten feed,	568	19.754	95.28	10.20	14.22	23.46	47.89	4.23
XX.	5	II.	English hay and gluten feed,	601	22.118	95.56	10.97	14.56	24.54	45.95	3.98
XX.	6	IV.	English hay,	644	30.050	95.95	8.89	9.57	29.47	48.50	3.57
XX.	7	V.	English hay and soy bean hay,	579	28.468	94.89	11.36	10.29	32.30	43.20	2.85
XX.	7	VI.	English hay and soy bean hay,	619	28.790	95.05	10.96	9.25	34.41	42.70	2.68
XX.	8	IV.	English hay and carrots,	475	22.861	94.84	13.03	10.51	27.07	45.38	4.01
XX.	8	V.	English hay and carrots,	409	20.063	94.92	13.27	11.08	25.18	46.38	4.14
XX.	8	VI.	English hay and carrots,	440	20.806	94.40	14.89	10.50	25.90	44.58	4.13
XX.	9	IV.	English hay, gluten feed and carrots,	629	25.091	95.68	11.26	11.78	24.70	48.45	3.81
XX.	9	V.	English hay, gluten feed and carrots,	522	23.376	95.37	11.24	11.64	24.03	49.22	3.87
XX.	9	VI.	English hay, gluten feed and carrots,	509	21.084	95.33	12.23	11.53	24.30	47.79	4.15

TABLE II. — COMPOSITION OF FECES (PER CENT.) — *Continued.*

Series.	Period.	Sheep.	FEEDS.	Average Daily Feces (Grams).	One-tenth Feces Air-dry (Grams).	Dry Matter in Air-dry Feces.	DRY MATTER BASIS.				
							Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XX.	10	VII.	English hay,	601	24.484	96.33	8.66	9.01	29.97	49.07	3.29
XX.	10	VIII.	English hay,	512	22.890	96.14	9.04	9.56	29.84	47.95	3.61
XX.	11	IV.	English hay, gluten feed and New Bedford pig meal,	582	29.587	95.22	15.16	14.44	25.00	42.98	2.42
XX.	11	V.	English hay, gluten feed and New Bedford pig meal,	692	26.733	95.13	16.34	15.79	22.78	42.55	2.54
XX.	11	VI.	English hay, gluten feed and New Bedford pig meal,	557	29.520	95.25	16.09	13.85	24.59	43.24	2.23
XX.	12	VII.	English hay and wheat gluten flour,	522	23.880	95.35	8.42	9.98	29.02	48.98	3.60
XX.	12	VIII.	English hay and wheat gluten flour,	596	23.559	95.33	8.82	10.67	27.96	49.03	3.52
XX.	13	IV.	English hay, gluten feed and vegetable ivory meal,	636	26.303	94.55	9.57	13.11	24.55	48.91	3.86
XX.	13	V.	English hay, gluten feed and vegetable ivory meal,	588	24.274	94.36	10.11	13.33	23.73	48.77	4.06
XX.	13	VI.	English hay, gluten feed and vegetable ivory meal,	555	23.789	94.18	10.81	12.91	23.67	48.28	4.33
XX.	14	IV.	English hay and gluten feed,	543	27.100	94.84	9.89	10.36	27.32	48.73	3.70
XX.	14	V.	English hay and gluten feed,	516	25.096	94.88	10.40	11.01	25.29	48.96	4.35
XX.	14	VI.	English hay and gluten feed,	503	24.679	95.14	10.11	10.95	25.70	49.27	3.97
XXI.	1	IV.	English hay and gluten feed,	491	23.619	92.98	11.96	10.86	26.32	46.84	4.02
XXI.	1	V.	English hay and gluten feed,	463	22.251	92.95	14.14	11.46	25.45	44.83	4.12
XXI.	1	VI.	English hay and gluten feed,	465	21.177	93.24	13.29	11.44	24.80	46.22	4.25
XXI.	2	VII.	English hay,	951	30.113	93.45	10.99	9.71	29.23	46.46	3.61

XXI.	2	VIII.	English hay, ...	729	25.607	93.30	11.25	10.83	26.74	47.09	4.09
XXI.	3	IV.	English hay, gluten feed and vegetable ivory meal, . .	612	25.816	94.13	10.06	13.32	25.25	47.43	3.94
XXI.	3	V.	English hay, gluten feed and vegetable ivory meal, . .	578	25.324	94.20	14.10	13.45	22.52	45.75	4.18
XXI.	3	VI.	English hay, gluten feed and vegetable ivory meal, . .	528	24.826	94.03	11.40	13.69	25.27	45.50	4.14
XXI.	4	VII.	English hay and wheat gluten flour, ...	737	29.360	94.85	9.41	9.28	30.42	47.29	3.60
XXI.	5	IV.	English hay, potato starch and gluten meal, . . .	389	13.577	94.77	12.25	13.71	25.81	43.70	4.53
XXI.	5	V.	English hay, potato starch and gluten meal, . . .	263	11.325	94.80	16.50	14.04	21.87	42.86	4.73
XXI.	5	VI.	English hay, potato starch and gluten meal, . . .	292	13.214	94.80	13.53	13.69	24.88	43.48	4.42
XXI.	6	IV.	English hay, potato starch, gluten meal and distillers' grains,	502	19.628	94.91	9.61	15.11	24.29	46.41	4.58
XXI.	6	V.	English hay, potato starch, gluten meal and distillers' grains,	515	19.084	94.94	10.95	16.39	22.02	45.98	4.66
XXI.	6	VI.	English hay, potato starch, gluten meal and distillers' grains,	496	18.996	94.97	10.95	15.61	23.33	44.89	5.22
XXI.	7	IV.	English hay, potato starch, gluten meal and corn bran, .	483	16.470	95.61	9.36	14.32	23.02	49.02	4.28
XXI.	7	V.	English hay, potato starch, gluten meal and corn bran, .	532	15.782	95.59	9.89	18.64	19.51	47.54	4.42
XXI.	7	VI.	English hay, potato starch, gluten meal and corn bran, .	376	16.938	95.70	11.57	13.62	25.05	46.01	3.75
XXI.	8	IV.	English hay, gluten feed and New Bedford tankage, . .	596	28.648	95.01	13.18	15.79	24.83	43.10	3.10
XXI.	8	V.	English hay, gluten feed and New Bedford tankage, . .	542	24.460	94.76	13.99	18.80	20.73	43.19	3.29
XXI.	8	VI.	English hay, gluten feed and New Bedford tankage, . .	508	24.768	94.99	14.23	16.82	23.25	42.74	2.96
XXI.	9	IX.	English hay, ...	798	22.828	95.09	10.01	10.40	28.91	47.25	3.43
XXI.	9	X.	English hay, ...	620	24.422	95.29	9.15	9.13	30.15	47.95	3.62
XXI.	9	XI.	English hay, ...	689	25.755	95.22	9.43	9.74	30.50	46.81	3.52
XXI.	10	IV.	English hay and wheat gluten flour, ...	574	26.412	95.64	9.62	10.10	29.30	46.82	4.16
XXI.	10	VI.	English hay and wheat gluten flour, ...	670	28.847	95.64	9.99	10.20	27.97	47.72	4.12

TABLE II. — COMPOSITION OF FECES (PER CENT.) — *Concluded.*

Series.	Period.	Sheep.	FEEDS.	Average Daily Feces (Grams).	One-tenth Feces Air-dry (Grams).	Dry Matter in Air-dry Feces.	DRY MATTER BASIS.				
							Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XXI.	11	V.	English hay and gluten feed,	414	19.858	94.61	14.97	14.13	22.69	43.85	4.36
XXI.	11	VI.	English hay and gluten feed,	416	19.337	94.92	16.77	14.05	21.58	43.31	4.29
XXI.	12	V.	English hay, gluten feed and feterita,	733	24.474	93.80	15.47	15.56	21.59	42.94	4.44
XXI.	12	VI.	English hay, gluten feed and feterita,	663	24.361	93.82	14.11	17.34	21.19	42.69	4.67
XXI.	13	XII.	English hay,	639	25.931	94.09	13.10	10.72	28.03	44.83	3.32
XXI.	13	XIII.	English hay,	698	26.630	94.02	13.34	10.58	29.04	43.52	3.52
XXI.	13	XIV.	English hay,	804	28.022	94.07	12.88	10.78	29.11	43.97	3.26
XXI.	14	IV.	English hay and sweet clover,	610	30.246	90.75	13.02	10.97	31.48	40.99	3.54
XXI.	14	VI.	English hay and sweet clover,	515	27.007	90.84	13.99	11.44	29.59	41.09	3.89
XXII.	1	IV.	English hay and Sudan grass,	711	31.687	93.03	13.47	12.19	24.69	46.04	3.61
XXII.	1	VI.	English hay and Sudan grass,	646	31.878	92.85	14.38	11.36	24.58	45.84	3.84
XXII.	2	IV.	English hay,	573	28.559	93.10	13.83	10.34	26.69	45.26	3.88
XXII.	2	VI.	English hay,	524	27.671	92.84	14.86	12.01	25.37	43.72	4.04
XXII.	3	IV.	English hay and Sudan grass,	683	30.929	93.90	13.40	13.28	23.28	46.80	3.24
XXII.	3	VI.	English hay and Sudan grass,	639	31.386	93.30	13.84	12.58	23.47	46.89	3.22
XXII.	4	IX.	English hay and Sudan grass,	739	27.021	95.49	8.18	10.68	28.77	50.40	1.97
XXII.	4	XI.	English hay and Sudan grass,	851	29.287	95.24	9.40	11.10	27.83	49.59	2.08
XXII.	6	IX.	Sudan grass,	828	26.671	94.32	10.55	13.53	25.80	47.42	2.70

XXII.	7	XI.	Sudan grass,	843	28.326	94.24	10.12	14.37	25.46	47.33	2.72
XXII.	7	XII.	Sudan grass,	673	25.321	94.52	10.39	14.82	24.54	47.04	3.21
XXII.	7	XIII.	Sudan grass,	761	25.447	94.61	10.12	14.22	25.71	47.06	2.89
XXII.	8	IV.	English hay,	622	29.557	94.43	10.46	10.57	27.82	47.80	3.35
XXII.	8	VI.	English hay,	579	28.237	94.45	10.69	10.82	27.23	47.81	3.45
XXII.	9	IX.	English hay and vinegar grains,	791	30.994	96.02	9.12	12.74	26.28	48.87	2.99
XXII.	9	XI.	English hay and vinegar grains,	1,332	31.883	93.17	9.80	13.34	25.77	48.29	2.80
XXII.	10	IV.	English hay and vinegar grains,	646	28.543	95.50	9.39	12.98	25.35	49.21	3.07
XXII.	10	VI.	English hay and vinegar grains,	619	28.157	95.28	10.80	13.79	23.51	48.63	3.27
XXII.	11	IV.	English hay and Stevens' "44" Dairy Ration,	643	26.957	95.39	10.46	12.09	26.71	47.64	3.10
XXII.	11	VI.	English hay and Stevens' "44" Dairy Ration,	719	27.779	95.82	11.62	12.81	24.74	47.44	3.39
XXII.	12	IV.	Alfalfa (third cutting, fine),	662	30.621	95.91	8.42	9.68	44.87	33.23	3.80
XXII.	12	VI.	Alfalfa (third cutting, fine),	1,113	30.053	95.40	9.60	10.66	42.81	33.34	3.59
XXII.	13	XII.	English hay,	671	26.875	95.33	9.19	9.46	30.63	47.33	3.39
XXII.	13	XIII.	English hay,	733	28.136	94.82	9.53	10.00	30.03	47.18	3.26
XXII.	14	XII.	Alfalfa (third cutting, fine),	847	26.907	95.87	8.58	10.63	44.44	32.79	3.56
XXII.	14	XIII.	Alfalfa (third cutting, fine),	871	27.750	95.51	8.26	10.01	45.80	32.57	3.36
XXII.	15	XII.	Rowen,	589	25.910	96.20	13.63	13.17	22.90	44.21	6.09
XXII.	15	XIII.	Rowen,	700	25.774	95.85	13.43	13.33	23.14	44.35	5.75
XXII.	16	IX.	Sweet clover and hay,	644	24.607	92.78	11.12	11.65	29.55	43.64	4.04
XXII.	16	XI.	Sweet clover and hay,	525	23.136	92.72	10.76	11.20	30.16	44.20	3.68
XXII.	17	XII.	English hay and Sudan grass,	649	23.501	91.80	7.54	11.21	27.13	50.59	3.53
XXII.	17	XIII.	English hay and Sudan grass,	580	25.304	93.18	11.38	10.34	27.95	46.71	3.62

TABLE III. — WEIGHT OF ANIMALS AT BEGINNING AND END OF EACH PERIOD, AND AVERAGE DAILY WATER CONSUMED.

Series.	Period.	Sheep.	FEEDS.	Average Water consumed (Cubic Centimeters).	BEGINNING (POUNDS).		END (POUNDS).	
					First Weight.	Second Weight.	First Weight.	Second Weight.
XVIII.	3	V.	English hay and mangels,	393	173.50	172.75	169.50	169.00
XVIII.	3	VI.	English hay and mangels,	1,012	161.50	161.50	158.50	158.50
XVIII.	4	I.	English hay and cabbage (heads),	384	140.75	140.75	134.75	134.75
XVIII.	4	II.	English hay and cabbage (heads),	999	135.50	136.00	133.50	134.50
XVIII.	5	I.	English hay and cabbage (leaves),	1,040	134.00	134.50	133.00	133.00
XVIII.	5	II.	English hay and cabbage (leaves),	1,530	134.00	134.00	132.00	132.50
XVIII.	6	V.	English hay and mangels,	371	173.25	171.50	160.75	159.25
XVIII.	6	VI.	English hay and mangels,	1,656	170.75	168.50	161.00	158.75
XVIII.	7	V.	English hay and turnips (Swedish),	363	167.25	166.25	157.65	155.75
XVIII.	7	VI.	English hay and turnips (Swedish),	1,544	165.50	165.75	156.00	156.00
XIX.	2	V.	English hay and gluten feed,	2,589	132.75	131.50	129.75	130.00
XIX.	2	VI.	English hay and gluten feed,	1,183	157.25	158.50	155.25	152.75
XIX.	3	I.	English hay,	2,367	144.00	143.50	141.25	140.50
XIX.	3	II.	English hay,	2,551	161.25	161.50	159.25	159.50
XIX.	4	I.	English hay and pumpkins (seed removed),	321	133.00	132.25	131.50	131.75
XIX.	4	II.	English hay and pumpkins (seed removed),	434	150.00	149.50	148.25	148.00
XIX.	5	V.	English hay, gluten feed and vegetable ivory meal,	2,049	140.50	138.00	137.25	137.25

XIX.	5	VI.	English hay, gluten feed and vegetable ivory meal,	1,156	161.00	159.25	163.50	165.50
XIX.	6	I.	English hay and pumpkins (entire),	469	136.00	135.75	135.00	135.50
XIX.	6	II.	English hay and pumpkins (entire),	704	149.75	148.75	149.25	149.50
XIX.	7	I.	English hay and cabbage (whole),	294	133.25	132.50	131.25	131.25
XIX.	7	II.	English hay and cabbage (whole),	1,489	148.50	147.75	146.75	145.75
XIX.	8	I.	English hay and carrots,	494	135.75	135.50	135.00	134.75
XIX.	8	II.	English hay and carrots,	1,653	147.00	147.25	148.25	147.50
XIX.	9	V.	English hay,	3,471	139.00	139.00	138.75	139.25
XIX.	9	VI.	English hay,	1,189	169.50	169.00	166.25	167.00
XIX.	10	III.	English hay, potato starch and gluten meal,	773	158.00	156.00	146.00	144.75
XIX.	10	IV.	English hay, potato starch and gluten meal,	3,080	186.50	184.50	180.75	179.75
XIX.	11	IV.	English hay, potato starch and gluten meal,	3,698	179.25	178.25	178.00	177.50
XIX.	12	IV.	English hay, potato starch, gluten meal and distillers' grains,	4,408	181.50	178.00	179.25	178.00
XIX.	13	I.	English hay and corn bran,	2,746	135.00	133.75	132.50	133.25
XIX.	13	II.	English hay and corn bran,	2,402	158.25	158.00	157.50	156.25
XIX.	14	V.	English hay and gluten feed,	2,416	132.50	131.50	136.00	137.00
XIX.	14	VI.	English hay and gluten feed,	1,559	162.50	161.75	160.75	163.75
XIX.	15	V.	English hay and gluten feed,	1,604	138.50	137.50	136.50	137.50
XIX.	15	VI.	English hay and gluten feed,	1,674	167.25	166.50	168.00	161.25
XX.	1	I.	English hay,	1,742	125.00	124.25	124.50	124.25
XX.	1	II.	English hay,	1,647	128.75	129.50	129.75	128.50
XX.	2	I.	English hay and pumpkins (entire),	115	120.25	120.25	120.25	120.50
XX.	2	II.	English hay and pumpkins (entire),	619	121.00	120.25	123.25	123.00

TABLE III. — WEIGHT OF ANIMALS AT BEGINNING AND END OF EACH PERIOD, AND AVERAGE DAILY WATER CONSUMED — *Continued.*

Series.	Period.	Sheep.	FEEDS.	Average Water consumed (Cubic Centimeters).	BEGINNING (POUNDS).		END (POUNDS).	
					First Weight.	Second Weight.	First Weight.	Second Weight.
XX.	3	I.	English hay, gluten feed and pumpkins (entire),	731	124.50	125.25	127.50	126.50
XX.	3	II.	English hay, gluten feed and pumpkins (entire),	815	126.00	127.25	128.25	128.00
XX.	4	I.	English hay, gluten feed and pumpkins (entire),	24	127.00	127.00	127.50	128.75
XX.	4	II.	English hay, gluten feed and pumpkins (entire),	123	132.25	132.25	132.25	131.25
XX.	5	I.	English hay and gluten feed,	1,533	124.25	124.50	125.75	126.50
XX.	5	II.	English hay and gluten feed,	1,584	130.25	129.75	127.50	128.75
XX.	6	IV.	English hay,	2,351	173.25	172.75	170.25	170.00
XX.	7	V.	English hay and soy bean hay,	1,049	147.75	148.75	141.00	143.00
XX.	7	VI.	English hay and soy bean hay,	1,353	152.50	151.25	152.00	152.00
XX.	8	IV.	English hay and carrots,	1,686	166.00	167.00	162.25	159.25
XX.	8	V.	English hay and carrots,	298	141.00	141.50	144.75	144.25
XX.	8	VI.	English hay and carrots,	923	149.75	152.00	148.50	147.75
XX.	9	IV.	English hay, gluten feed and carrots,	2,520	163.75	163.25	164.50	163.00
XX.	9	V.	English hay, gluten feed and carrots,	795	144.50	143.00	145.75	145.00
XX.	9	VI.	English hay, gluten feed and carrots,	1,461	148.25	148.25	149.75	149.75
XX.	10	VII.	English hay,	1,824	86.75	86.50	86.50	86.50
XX.	10	VIII.	English hay,	1,565	94.75	94.50	93.25	93.00

XX.	11	IV.	English hay, gluten feed and New Bedford pig meal,	3,650	170.25	169.50	167.00	166.50
XX.	11	V.	English hay, gluten feed and New Bedford pig meal,	1,546	146.75	147.25	147.25	147.75
XX.	11	VI.	English hay, gluten feed and New Bedford pig meal,	1,879	157.00	157.00	154.00	154.00
XX.	12	VII.	English hay and wheat gluten,	1,987	91.50	90.00	87.75	87.25
XX.	12	VIII.	English hay and wheat gluten,	1,956	97.25	96.25	96.50	96.25
XX.	13	IV.	English hay, gluten feed and vegetable ivory meal,	4,707	173.50	171.50	170.50	169.50
XX.	13	V.	English hay, gluten feed and vegetable ivory meal,	1,934	154.25	154.75	151.00	153.75
XX.	13	VI.	English hay, gluten feed and vegetable ivory meal,	2,193	157.00	157.00	156.00	156.25
XX.	14	IV.	English hay and gluten meal,	4,509	174.00	173.00	173.25	170.50
XX.	14	V.	English hay and gluten meal,	1,436	148.50	151.00	152.25	152.00
XX.	14	VI.	English hay and gluten meal,	2,207	157.25	156.50	155.75	155.50
XXI.	1	IV.	English hay and gluten feed,	3,497	156.75	158.50	158.00	157.75
XXI.	1	V.	English hay and gluten feed,	1,238	125.50	126.00	127.25	129.50
XXI.	1	VI.	English hay and gluten feed,	1,856	136.25	136.25	134.25	134.75
XXI.	2	VII.	English hay,	1,960	86.75	85.75	84.50	84.75
XXI.	2	VIII.	English hay,	1,621	93.50	94.00	94.50	94.25
XXI.	3	IV.	English hay, gluten feed and vegetable ivory meal,	2,641	159.00	160.00	159.00	158.50
XXI.	3	V.	English hay, gluten feed and vegetable ivory meal,	1,321	130.00	127.75	131.00	128.25
XXI.	3	VI.	English hay, gluten feed and vegetable ivory meal,	1,898	138.25	138.00	137.50	138.25
XXI.	4	VII.	English hay and wheat gluten flour,	1,743	84.25	84.25	83.00	82.50
XXI.	5	IV.	English hay, potato starch and gluten meal,	1,535	156.50	154.25	154.00	154.75
XXI.	5	V.	English hay, potato starch and gluten meal,	890	119.50	118.25	121.00	123.25
XXI.	5	VI.	English hay, potato starch and gluten meal,	852	130.25	131.50	126.00	126.50

Table III. — Weight of Animals at Beginning and End of Each Period, and Average Daily Water consumed — *Continued.*

Series.	Period.	Sheep.	Feeds.	Average Water consumed (Cubic Centimeters).	Beginning (Pounds).		End (Pounds).	
					First Weight.	Second Weight.	First Weight.	Second Weight.
XXI.	6	IV.	English hay, potato starch, gluten meal and distillers' grains, . .	2,899	157.50	156.00	156.50	156.50
XXI.	6	V.	English hay, potato starch, gluten meal and distillers' grains, . .	951	124.50	122.25	126.50	124.00
XXI.	6	VI.	English hay, potato starch, gluten meal and distillers' grains, . .	2,091	128.00	127.25	128.00	126.00
XXI.	7	IV.	English hay, potato starch, gluten meal and corn bran, . . .	3,296	157.00	155.25	157.00	156.25
XXI.	7	V.	English hay, potato starch, gluten meal and corn bran, . . .	1,360	124.50	122.50	127.00	124.50
XXI.	7	VI.	English hay, potato starch, gluten meal and corn bran, . . .	1,676	130.75	130.25	130.50	130.50
XXI.	8	IV.	English hay, gluten feed and New Bedford tankage, . . .	3,924	161.25	160.50	158.50	159.25
XXI.	8	V.	English hay, gluten feed and New Bedford tankage, . . .	1,978	128.50	129.75	133.50	133.00
XXI.	8	VI.	English hay, gluten feed and New Bedford tankage, . . .	2,011	136.75	136.50	136.50	137.00
XXI.	9	IX.	English hay, ...	1,536	72.00	71.75	73.00	72.75
XXI.	9	X.	English hay, ...	1,178	70.50	69.75	66.25	70.25
XXI.	9	XI.	English hay, ...	1,209	76.00	79.25	79.00	79.25
XXI.	10	IV.	English hay and wheat gluten flour, ...	3,368	163.50	162.25	162.75	163.75
XXI.	10	VI.	English hay and wheat gluten flour, ...	2,146	140.50	140.25	139.25	140.25
XXI.	11	V.	English hay and gluten feed, ...	1,706	123.00	123.00	124.00	124.50
XXI.	11	VI.	English hay and gluten feed, ...	2,346	133.50	133.50	133.00	133.25
XXI.	12	V.	English hay, gluten feed and feterita, ...	2,195	123.50	124.00	126.00	126.00

XXI.	12	VI.	English hay, gluten feed and feterita,	2,153	135.50	136.75	137.75	137.00
XXI.	13	XII.	English hay,	2,824	98.50	95.50	94.75	95.00
XXI.	13	XIII.	English hay,	2,006	86.00	84.25	83.25	84.25
XXI.	13	XIV.	English hay,	1,825	86.50	85.75	83.75	84.25
XXI.	14	IV.	English hay and sweet clover,	1,708	150.50	149.00	146.00	146.00
XXI.	14	VI.	English hay and sweet clover,	986	126.50	126.00	127.00	127.25
XXII.	1	IV.	English hay and Sudan grass,	1,872	153.25	152.00	151.25	151.50
XXII.	1	VI.	English hay and Sudan grass,	842	138.25	135.00	132.25	132.75
XXII.	2	IV.	English hay,	2,889	149.50	148.00	146.50	147.00
XXII.	2	VI.	English hay,	1,663	132.00	130.25	131.50	130.50
XXII.	3	IV.	English hay and Sudan grass,	3,122	147.75	148.50	148.75	149.25
XXII.	3	VI.	English hay and Sudan grass,	1,740	133.75	131.75	129.00	129.00
XXII.	4	IX.	English hay and Sudan grass,	1,387	85.00	85.00	85.00	85.00
XXII.	4	XI.	English hay and Sudan grass,	1,362	95.75	95.25	94.75	93.50
XXII.	6	IX.	Sudan grass,	1,757	84.75	84.75	84.75	83.00
XXII.	7	XI.	Sudan grass,	1,938	91.00	88.25	88.50	87.75
XXII.	7	XII.	Sudan grass,	1,875	84.25	83.75	83.50	82.75
XXII.	7	XIII.	Sudan grass,	2,009	98.25	98.75	97.75	97.50
XXII.	8	IV.	English hay,	1,956	154.50	153.00	150.25	149.25
XXII.	8	VI.	English hay,	1,619	135.75	136.5	134.25	133.75
XXII.	9	IX.	English hay and vinegar grains,	1,804	90.00	89.50	91.25	91.25
XXII.	9	XI.	English hay and vinegar grains,	2,015	92.25	90.50	90.25	90.00
XXII.	10	IV.	English hay and vinegar grains,	3,250	147.75	147.25	146.25	146.75

TABLE III. — WEIGHT OF ANIMALS AT BEGINNING AND END OF EACH PERIOD, AND AVERAGE DAILY WATER CONSUMED — *Concluded.*

Series.	Period.	Sheep.	FEEDS.	Average Water consumed (Cubic Centimeters).	BEGINNING (POUNDS).		END (POUNDS).	
					First Weight.	Second Weight.	First Weight.	Second Weight.
XXII.	10	VI.	English hay and vinegar grains,	1,782	128.25	129.75	131.25	131.00
XXII.	11	IV.	English hay and Stevens' "44" Dairy Ration,	3,462	145.75	146.25	146.25	146.00
XXII.	11	VI.	English hay and Stevens' "44" Dairy Ration,	1,766	133.50	132.25	131.75	129.75
XXII.	12	IV.	Alfalfa (third cutting, fine),	3,685	146.75	147.00	145.00	143.50
XXII.	12	VI.	Alfalfa (third cutting, fine),	2,203	127.00	127.75	128.00	129.00
XXII.	13	XII.	English hay,	1,781	102.00	101.75	101.00	101.00
XXII.	13	XIII.	English hay,	2,068	88.50	87.75	87.50	87.50
XXII.	14	XII.	Alfalfa (third cutting, fine),	2,204	96.50	96.00	93.75	93.50
XXII.	14	XIII.	Alfalfa (third cutting, fine),	2,153	84.75	85.00	83.00	82.50
XXII.	15	XII.	Rowen,	2,041	97.00	96.25	98.00	97.50
XXII.	15	XIII.	Rowen,	1,875	84.75	85.25	85.75	86.00
XXII.	16	IX.	Sweet clover and hay,	1,083	97.00	96.75	99.75	101.75
XXII.	16	XI.	Sweet clover and hay,	784	97.50	96.50	100.50	101.75
XXII.	17	XII.	English hay and Sudan grass,	1,027	96.50	97.50	95.25	95.25
XXII.	17	XIII.	English hay and Sudan grass,	1,465	87.00	88.50	87.25	89.75

TABLE IV. — DIGESTION COEFFICIENTS OF BASAL RATIONS USED IN THE COMPUTATION OF DIGESTION COEFFICIENTS.

Series.	Period.	Sheep.	BASAL RATION.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	SOURCE OF DATA.	
										Series.	Period.
XVIII.	4 and 5,	I. and II.,	English hay,	65	31	61	70	67	53	XVIII.	I.[1]
XVIII.	3, 6 and 7,	V. and VI.,	English hay,	65	46	65	67	67	46	XVII.	VIII.[2]
XIX.	2, 10 and 11,	I., II., V. and VI.,	English hay,	59	28	52	62	62	47	XIX.	III. and IX.[3]
XIX.	10 and 11,	– –	Corn starch,	100	–	–	–	100	–	–	–[4]
XIX.	4, 6, 7, 8 and 13,	I. and II.,	English hay,	59	22	51	62	63	38	XIX.	III.
XIX.	12,	IV.,	English hay, corn starch and gluten meal.	72	31	75	61	78	47	XIX.	XI.
XIX.	5,	V. and VI.,	English hay and gluten feed,	66	31	68	66	70	56	XIX.	II.
XIX.	14 and 15,	V. and VI.,	English hay and gluten feed,	59	33	52	61	62	56	XIX.	IX.
XX.	2,	I. and II.,	English hay,	64	38	51	69	66	48	XX.	I.
XX.	3 and 4,	I. and II.,	English hay and gluten feed,	67	35	64	72	72	59	XX.	V.
XX.	7 and 8,	IV., V. and VI.,	English hay,	63	40	50	67	65	45	XX.	I and IV.[3]
XX.	9, 11 and 13,	IV., V. and VI.,	English hay and gluten feed,	62	29	64	64	65	50	XX.	XIV.
XX.	12,	VII. and VIII.,	English hay,	59	47	41	63	62	47	XX.	X.
XXI.	1 and 5,	IV., V. and VI.,	English hay,	57	38	43	61	60	43	XXI.	II. and IX.[3]
XXI.	3 and 8,	IV., V. and VI.,	English hay and gluten feed,	67	29	69	68	71	48	XXI.	I.

[1] See Bulletin No. 152, pp. 94, 99.

[2] See Bulletin No. 152, pp. 83, 93.

[3] Average coefficients of two experiments.

[4] Corn starch in all cases assumed to be entirely digested.

Table IV. — Digestion Coefficients of Basal Rations used in the Computation of Digestion Coefficients — *Concluded.*

Series.	Period.	Sheep.	Basal Ration.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Source of Data.	
										Series.	Period.
XXI.	4,	VII.,	English hay,	58	33	44	63	62	44	XXI.	II.
XXI.	5,	– –	Corn starch,	100	–	–	–	100	–	–	–[1]
XXI.	6 and 7,	IV., V. and VI.,	English hay, potato starch and gluten meal.	75	14	73	68	82	36	XXI.	V.
XXI.	11 and 14,	IV., V. and VI.,	English hay,	59	37	53	63	64	51	XXI.	XIII.
XXI.	12,	V. and VI.,	English hay and gluten feed,	71	38	71	75	75	50	XXI.	XI.
XXII.	1 and 3,	IV. and VI.,	English hay,	62	28	51	69	66	41	XXII.	II.
XXII.	9, 10 and 11,	IV. and VI.,	English hay,	61	41	51	68	63	45	XXII.	VIII.
XXII.	16,	IX. and XI.,	English hay,	58	45	48	63	60	45	XXIII.	I.[2]
XXII.	17,	XII. and XIII.,	English hay,	59	46	51	62	60	43	XXII.	XIII.

[1] Corn starch in all cases assumed to be entirely digested.

[2] Unpublished to date.

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS.

SERIES XVIII., MANGELS, PERIOD 3.

Sheep V.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
400 grams English hay fed,	347.00	19.67	34.25	109.51	174.24	9.33
1,400 grams mangels fed,	228.76	13.57	12.03	13.63	188.89	.64
Amount consumed,	575.76	33.24	46.28	123.14	363.13	9.97
Minus 159.94 grams feces excreted,	151.42	23.98	19.06	35.67	65.43	7.28
Amount digested,	424.34	9.26	27.22	87.47	297.70	2.69
Minus hay digested,	225.55	9.05	22.26	73.37	116.76	4.29
Mangels digested,	198.79	.21	4.96	14.10	180.94	–
Per cent. digested,	86.90	1.55	41.21	103.45	95.79	–

Sheep VI.

Amount consumed as above,	575.76	33.24	46.26	123.14	363.13	9.97
Minus 155.50 grams feces excreted,	147.21	21.73	17.86	35.62	64.49	7.51
Amount digested,	428.55	11.51	28.42	87.52	298.64	2.46
Minus hay digested,	225.55	9.05	22.26	73.37	116.76	4.29
Mangels digested,	203.00	2.46	6.16	14.15	181.88	–
Per cent. digested,	88.74	18.12	51.18	103.81	96.29	–
Average per cent. digested,	87.82	9.84	46.20	103.73	96.04	–

SERIES XVIII., CABBAGE (HEADS), PERIOD 4.

Sheep I.

400 grams English hay fed,	357.40	18.80	33.06	111.97	184.06	9.51
1,600 grams cabbage (heads) fed,	154.56	12.70	27.79	15.21	97.02	1.84
Amount consumed,	511.96	31.50	60.85	127.18	281.08	11.35
Minus 131.90 grams feces excreted,	125.34	15.44	17.08	29.82	57.67	5.33
Amount digested,	386.62	16.06	43.77	97.36	223.41	6.02
Minus hay digested,	232.31	5.83	20.17	78.38	123.32	5.04
Cabbage digested,	154.31	10.23	23.60	18.98	100.09	.98
Per cent. digested,	99.84	80.55	84.92	124.79	103.16	53.26

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XVIII., CABBAGE (HEADS), PERIOD 4 — *Concluded.*

Sheep II.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	511.96	31.50	60.85	127.18	281.08	11.35
Minus 138.19 grams feces excreted,	131.56	16.27	16.64	33.63	59.30	5.72
Amount digested,	380.40	15.23	44.21	93.55	221.78	5.63
Minus hay digested,	232.31	5.83	20.17	78.38	123.32	5.04
Cabbage digested,	148.09	9.40	24.04	15.17	98.46	.59
Per cent. digested,	95.81	74.02	86.51	99.74	101.48	32.07
Average per cent. digested,	97.83	77.29	85.72	112.32	102.32	42.67

SERIES XVIII., CABBAGE (LEAVES), PERIOD 5.

Sheep I.

400 grams English hay fed,	355.20	20.32	33.64	111.82	179.08	10.34
1,200 grams cabbage (leaves) fed,	228.60	33.12	27.29	29.99	132.69	5.51
Amount consumed,	583.80	53.44	60.93	141.81	311.77	15.85
Minus 186.23 grams feces excreted,	177.27	32.00	22.21	39.35	75.84	7.87
Amount digested,	406.53	21.44	38.72	102.46	235.93	7.98
Minus hay digested,	230.88	6.30	20.52	78.27	119.98	5.48
Cabbage digested,	175.65	15.14	18.20	24.19	115.95	2.50
Per cent. digested,	76.84	45.71	66.69	80.66	87.38	45.37

Sheep II.

Amount consumed as above,	583.80	53.44	60.93	141.81	311.77	15.85
Minus 199.50 grams feces excreted,	189.72	32.46	23.79	40.81	83.91	8.75
Amount digested,	394.08	20.98	37.14	101.00	227.86	7.10
Minus hay digested,	230.88	6.30	20.52	78.27	119.98	5.48
Cabbage digested,	163.20	14.68	16.62	22.73	107.88	1.62
Per cent. digested,	71.39	44.23	60.90	75.79	81.30	29.40
Average per cent. digested,	74.12	44.97	63.80	78.23	84.34	37.39

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XVIII., MANGELS, PERIOD 6.

Sheep V.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
400 grams English hay fed,	355.68	23.23	33.40	115.06	174.67	9.32
1,800 grams mangels fed,	312.84	19.65	20.08	21.30	251.00	.81
Amount consumed,	668.52	42.88	53.48	136.36	425.67	10.13
Minus 179.45 grams feces excreted,	170.08	24.07	22.06	40.19	74.20	9.56
Amount digested,	498.44	18.81	31.42	96.17	351.47	.57
Minus hay digested,	231.19	10.69	21.71	77.09	117.03	4.29
Mangels digested,	267.25	8.12	9.71	19.08	234.44	–
Per cent. digested,	85.43	41.31	48.36	89.58	93.40	–

Sheep VI.

Amount consumed as above,	668.52	42.88	53.48	136.36	425.67	10.13
Minus 173.44 grams feces excreted,	164.54	21.90	19.12	41.10	73.52	8.90
Amount consumed,	503.98	20.98	34.36	95.26	352.15	1.23
Minus hay digested,	231.19	10.69	21.71	77.09	117.03	4.29
Mangels digested,	272.79	10.29	12.65	18.17	235.12	–
Per cent. digested,	87.20	52.36	63.00	85.31	93.67	–
Average per cent. digested,	81.32	46.84	55.68	87.45	93.58	–

SERIES XVIII., TURNIPS (SWEDISH), PERIOD 7.

Sheep V.

400 grams English hay fed,	356.28	23.12	33.21	111.41	179.03	9.51
1,600 grams turnips fed,	220.64	16.17	21.14	24.25	157.34	1.74
Amount consumed,	576.92	39.29	54.35	135.66	336.37	11.25
Minus 156.48 grams feces excreted,	149.45	19.70	17.93	39.74	66.19	5.89
Amount digested,	427.47	19.59	36.42	95.92	270.18	5.36
Minus hay digested,	231.58	10.64	21.59	74.64	119.95	4.37
Turnips digested,	195.89	8.95	14.83	21.28	150.23	.99
Per cent. digested,	88.78	55.34	70.15	87.75	95.48	56.90

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XVIII., TURNIPS (SWEDISH), PERIOD 7 — *Concluded.*

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	576.92	39.29	54.35	135.66	336.37	11.25
Minus 155.75 grams feces excreted,	148.59	20.34	15.62	42.70	64.37	5.56
Amount digested,	428.33	18.95	38.73	92.96	272.00	5.69
Minus hay digested,	231.58	10.64	21.59	74.64	119.95	4.37
Turnips digested,	196.75	8.31	17.14	18.32	152.05	1.32
Per cent. digested,	89.17	51.38	81.08	75.55	96.64	75.86
Average per cent. digested,	88.98	53.36	75.62	81.65	96.06	66.38

SERIES XIX., ENGLISH HAY AND GLUTEN FEED, — GLUTEN FEED, PERIOD 2.

Sheep V.

550 grams English hay fed,	484.11	28.22	46.09	152.01	246.80	10.99
150 grams gluten feed fed,	134.33	1.41	37.40	11.75	77.62	6.15
Amount consumed,	618.44	29.63	83.49	163.76	324.42	17.14
Minus 226.53 grams feces excreted,	209.47	19.38	26.79	57.86	97.92	7.52
Amount digested,	408.97	10.25	56.70	105.90	226.50	9.62
Minus hay digested,	285.62	7.90	23.97	94.25	153.02	5.16
Gluten feed digested,	123.35	2.35	32.73	11.65	73.48	4.46
Per cent. ration digested,	66.13	34.59	67.91	64.67	69.82	56.13
Per cent. gluten feed digested,	91.80	167.00	87.50	99.00	94.70	72.50

Sheep VI.

Amount consumed as above,	618.44	29.63	83.49	163.76	324.42	17.14
Minus 223 grams feces excreted,	206.48	21.62	26.06	54.70	96.65	7.45
Amount digested,	411.96	8.01	57.43	109.06	227.77	9.69
Minus hay digested,	285.62	7.90	23.97	94.25	153.02	5.16
Gluten feed digested,	126.34	.11	33.46	14.81	74.75	4.53
Per cent. ration digested,	66.61	27.03	68.79	66.60	70.21	56.53
Per cent. gluten feed digested,	94.70	.78	89.50	126.00	96.30	73.60
Average per cent. gluten feed digested,	93.25	83.89	88.50	112.50	95.50	73.05
Average per cent. ration digested,	66.37	30.81	68.35	65.64	70.02	56.33

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XIX., ENGLISH HAY, PERIOD 3.

Sheep I.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	696.00	40.79	65.77	215.34	358.51	15.59
Minus 296.19 grams feces excreted,	279.99	32.39	33.49	75.71	128.80	9.60
English hay digested,	416.01	8.40	32.28	139.63	229.71	5.99
Per cent. digested,	59.77	20.59	49.08	64.84	64.07	38.42

Sheep II.

800 grams English hay fed,	696.00	40.79	65.77	215.34	358.51	15.59
Minus 315.10 grams feces excreted,	294.78	31.04	30.83	88.43	134.84	9.64
English hay digested,	401.22	9.75	34.94	126.91	223.67	5.95
Per cent. digested,	57.65	23.90	53.12	58.93	62.39	38.17
Average per cent. digested,	58.71	22.25	51.10	61.89	63.23	38.30

SERIES XIX., PUMPKINS (SEEDS REMOVED), PERIOD 4.

Sheep I.

500 grams English hay fed,	437.35	25.85	41.20	137.68	222.04	10.58
2,000 grams pumpkins fed,	108.40	9.55	14.89	18.79	62.39	2.78
Amount consumed,	545.75	35.40	56.09	156.47	284.43	13.36
Minus 180.47 grams feces excreted,	169.30	19.67	21.30	45.27	76.54	6.52
Amount digested,	376.45	15.73	34.79	111.20	207.89	6.84
Minus hay digested,	258.04	5.69	21.01	85.36	139.89	4.02
Pumpkins digested,	118.41	10.04	13.78	25.84	68.00	2.82
Per cent. digested,	109.23	105.13	92.55	137.52	108.99	101.44

Sheep II.

Amount consumed as above,	545.75	35.40	56.09	156.47	284.43	13.36
Minus 198.05 grams feces excreted,	185.99	24.03	21.09	53.23	80.63	7.01
Amount digested,	359.76	11.37	35.00	103.24	203.80	6.35
Minus hay digested,	258.04	5.69	21.01	85.36	139.89	4.02
Pumpkins digested,	101.72	5.68	13.99	17.88	63.91	2.33
Per cent. digested,	93.84	59.48	93.96	95.16	102.44	83.81
Average per cent. digested,	101.54	82.31	93.26	116.34	105.72	92.63

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XIX., VEGETABLE IVORY MEAL, PERIOD 5.

Sheep V.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	484.28	28.14	45.67	153.52	245.91	11.04
150 grams gluten feed fed,	134.90	1.50	36.37	11.74	79.97	5.32
200 grams vegetable ivory meal fed,	174.72	2.39	10.52	12.27	148.33	1.21
Amount consumed,	793.90	32.03	92.56	177.53	474.21	17.57
Minus 252.10 grams feces excreted,	237.73	21.78	37.09	61.71	107.74	9.41
Amount digested,	556.17	10.25	55.47	115.82	366.47	8.16
Minus English hay and gluten feed digested,	408.66	9.19	55.79	109.07	228.12	9.16
Vegetable ivory meal digested,	147.51	1.06	-	6.75	138.35	-
Per cent. digested,	84.43	44.35	-	55.01	93.27	-

Sheep VI.

Amount consumed as above,	793.90	32.03	92.56	177.53	474.21	17.57
Minus 241.94 grams feces excreted,	228.63	22.41	33.61	57.93	106.82	7.86
Amount digested,	565.27	9.62	58.95	119.60	367.39	9.71
Minus English hay and gluten feed digested,	408.66	9.19	55.79	109.07	228.12	9.16
Vegetable ivory meal digested,	156.61	.43	3.16	10.53	139.27	.55
Per cent. digested,	89.63	17.99	30.04	85.82	93.89	45.45
Average per cent. digested,	87.03	31.17	30.04	70.42	93.58	45.45[1]

SERIES XIX., PUMPKINS (ENTIRE), PERIOD 6.

Sheep I.

550 grams English hay fed,	483.29	26.82	43.50	151.46	248.51	13.00
2,000 grams pumpkins fed,	176.20	13.39	31.22	29.71	76.01	25.87
Amount consumed,	659.49	40.21	74.72	181.17	324.52	38.87
Minus 253.33 grams feces excreted,	240.66	25.63	30.52	69.51	105.98	9.02
Amount digested,	418.83	14.58	44.20	111.66	218.54	29.85
Minus hay digested,	285.14	5.90	22.19	93.91	156.56	4.94
Pumpkins digested,	133.69	8.68	22.01	17.75	61.98	24.91
Per cent. digested,	75.87	64.82	70.50	59.74	81.54	96.29

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[1] One sheep only.

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XIX., PUMPKINS (ENTIRE), PERIOD 6 — *Concluded.*

Sheep II.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, ...	659.49	40.21	74.72	181.17	324.52	38.87
Minus 228.69 grams feces excreted, . .	216.96	25.75	27.34	61.62	93.38	8.87
Amount digested, ...	442.53	14.46	47.38	119.55	231.14	30.00
Minus hay digested, ...	285.14	5.90	22.19	93.91	156.56	4.94
Pumpkins digested, ...	157.39	8.56	25.19	25.64	74.58	25.06
Per cent. digested, ...	89.32	63.93	80.69	86.30	98.12	96.87
Average per cent. digested, ...	82.60	64.38	75.60	73.02	89.83	96.58

SERIES XIX., CABBAGE (WHOLE), PERIOD 7.

Sheep I.

450 grams English hay fed, ...	398.57	22.16	32.48	126.86	207.42	9.65
1,600 grams cabbage fed, ...	187.68	22.90	40.95	19.33	100.90	3.60
Amount consumed, ...	586.25	45.06	73.43	146.19	308.32	13.25
Minus 192.77 grams feces excreted, . .	183.40	26.50	22.23	46.36	81.29	7.02
Amount digested, ...	402.85	18.56	51.20	99.83	227.03	6.23
Minus hay digested, ...	235.16	4.88	16.56	78.65	130.67	3.67
Cabbage digested, ...	167.69	13.68	34.64	21.18	96.36	2.56
Per cent. digested, ...	89.35	59.74	84.59	109.57	95.50	71.11

Sheep II.

Amount consumed as above, ...	586.25	45.06	73.43	146.19	308.32	13.25
Minus 200.09 grams feces excreted, . .	189.95	27.77	20.97	53.53	80.56	7.12
Amount digested, ...	396.30	17.29	52.46	92.66	227.76	6.13
Minus hay digested, ...	233.98	4.88	16.56	78.65	130.67	3.67
Cabbage digested, ...	162.32	12.41	35.90	14.01	97.09	2.46
Per cent. digested, ...	86.49	54.19	87.67	72.48	96.22	68.33
Average per cent. digested, ...	87.92	56.97	86.13	91.03	95.86	69.72

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XIX., CARROTS, PERIOD 8.

Sheep I.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
500 grams English hay fed,	443.75	25.43	36.08	153.80	218.41	10.03
1,500 grams carrots fed,	188.10	16.10	15.05	15.52	139.27	2.16
Amount consumed,	631.85	41.53	51.13	169.32	357.68	12.19
Minus 211.46 grams feces excreted,	202.45	30.55	24.90	53.49	86.85	6.66
Amount digested,	449.40	10.98	26.23	115.83	270.83	5.53
Minus hay digested,	261.81	5.59	18.40	95.36	137.60	3.81
Carrots digested,	167.59	5.39	7.83	20.47	133.23	1.72
Per cent. digested,	89.10	33.48	52.03	131.89	95.66	79.63

Sheep II.

Amount consumed as above,	631.85	41.53	51.13	169.32	357.68	12.19
Minus 194.84 grams feces excreted,	186.79	28.47	21.01	49.97	80.93	6.41
Amount digested,	445.06	13.06	30.12	119.35	276.75	5.78
Minus hay digested,	261.81	5.59	18.40	95.36	137.60	3.81
Carrots digested,	183.25	7.47	11.72	23.99	139.15	1.97
Per cent. digested,	94.42	46.40	77.87	154.57	99.91	91.20
Average per cent. digested,	93.26	39.94	64.95	143.23	97.79	85.42

SERIES XIX., ENGLISH HAY, PERIOD 9.

Sheep V.

800 grams English hay fed,	710.00	40.75	60.49	221.66	363.53	23.57
Minus 294.67 grams feces excreted,	279.97	27.10	28.11	81.30	133.44	10.02
Hay digested,	430.03	13.65	32.38	140.36	230.09	13.55
Per cent. digested,	60.57	33.50	53.53	63.32	63.29	57.49

Sheep VI.

800 grams English hay fed,	710.00	40.75	60.49	221.66	363.53	23.57
Minus 317.10 grams feces excreted,	301.56	27.38	29.58	91.64	142.35	10.61
Hay digested,	408.44	13.37	30.91	130.02	221.18	12.96
Per cent. digested,	57.53	32.81	51.10	58.66	60.84	54.99
Average per cent. digested,	59.05	33.16	52.32	60.99	62.07	56.24

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XIX., ENGLISH HAY, POTATO STARCH AND GLUTEN MEAL (DIAMOND), — GLUTEN MEAL (DIAMOND), PERIOD 10.

Sheep III.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
300 grams English hay fed,	270.81	15.60	20.50	86.85	141.55	6.31
125 grams potato starch fed,	113.23	-	-	-	113.23	-
100 grams gluten meal (Diamond) fed,	94.40	.81	42.47	2.04	47.37	1.71
Amount consumed,	478.44	16.41	62.97	88.89	302.15	8.02
Minus 132.41 grams feces excreted,	127.01	10.88	16.70	35.89	58.27	5.27
Amount digested,	351.43	5.53	46.27	53.00	243.88	2.75
Minus hay and starch (100 per cent.) digested,	273.01	4.37	10.66	53.85	200.99	2.96
Gluten meal (Diamond) digested,	78.42	1.16	35.61	-	42.89	-
Per cent. ration digested,	73.45	33.70	73.48	59.62	80.71	34.29
Per cent. gluten meal (Diamond) digested,	83.07	143.20	83.85	-	90.54	-

Sheep IV.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	478.44	16.41	62.97	88.89	302.15	8.02
Minus 147.44 grams feces excreted,	141.26	14.24	18.25	39.64	63.73	5.40
Amount digested,	337.18	2.17	44.72	49.25	238.42	2.62
Minus hay and starch (100 per cent.) digested,	273.01	4.37	10.66	53.85	200.99	2.75
Gluten meal (Diamond) digested,	64.17	-	34.06	-	37.43	-
Per cent. ration digested,	70.47	13.22	71.02	55.41	78.91	32.67
Per cent. gluten meal (Diamond) digested,	68.00	-	80.00	-	79.00	-
Average per cent. ration digested,	71.96	23.46	72.25	57.52	79.81	33.48
Average per cent. gluten meal (Diamond) digested.	75.54	71.60	81.93	-	84.77	-

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XIX., ENGLISH HAY, POTATO STARCH AND GLUTEN MEAL (DIAMOND), — GLUTEN MEAL (DIAMOND), PERIOD 11.

Sheep IV.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
400 grams English hay fed, ...	369.40	20.91	25.93	118.47	195.37	8.72
125 grams potato starch fed, ...	112.80	–	–	–	112.80	–
125 grams gluten meal (Diamond) fed, .	117.25	1.34	52.52	2.16	58.86	2.37
Amount consumed, ...	599.45	22.25	78.45	120.63	367.03	11.09
Minus 174.32 grams feces excreted, . .	166.84	14.70	19.60	47.37	79.30	5.87
Amount digested, ...	432.61	7.55	58.85	73.26	287.73	5.22
Minus hay and starch (100 per cent.) digested,	330.75	5.85	13.48	73.45	233.93	4.10
Gluten meal (Diamond) digested, . .	101.86	1.70	45.37	–	53.80	1.12
Per cent. ration digested, ...	72.17	33.93	75.02	60.73	78.39	47.07
Per cent. gluten meal (Diamond) digested, .	86.90	127.00	86.40	–	91.40	47.30

SERIES XIX., DISTILLERS' GRAINS (CORN), PERIOD 12.

Sheep IV.

400 grams English hay fed, ...	359.00	21.72	26.42	115.10	184.99	10.77
125 grams gluten meal fed, ...	117.51	1.57	52.87	2.36	58.44	2.27
125 grams potato starch fed, ...	113.49	–	–	–	113.49	–
200 grams distillers' grains fed, . . .	187.72	3.44	55.28	23.69	86.73	18.58
Amount consumed, ...	777.72	26.73	134.57	141.15	443.65	31.62
Minus 240.66 grams feces excreted, . .	229.42	20.35	31.20	65.64	104.06	8.17
Amount digested, ...	548.30	6.38	103.37	75.51	339.59	23.45
Minus hay, potato starch and gluten meal digested.	424.80	7.92	59.44	71.65	278.40	6.13
Distillers' grains digested, ...	123.50	–	43.93	3.86	61.19	17.32
Per cent. digested, ...	65.79	–	79.47	16.29	70.55	93.22

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XIX., CORN BRAN, PERIOD 13.

Sheep I.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
400 grams English hay fed,	363.48	22.28	25.52	119.33	188.21	8.14
350 grams corn bran fed,	316.47	2.72	16.52	45.89	247.32	4.02
Amount consumed,	679.95	25.00	42.04	165.22	435.53	12.16
Minus 191.02 grams feces excreted,	180.42	14.38	20.82	45.39	93.77	6.06
Amount digested,	499.53	10.62	21.22	119.83	341.76	6.10
Minus hay digested,	214.45	4.90	13.02	73.98	118.57	3.09
Corn bran digested,	285.08	5.72	8.20	45.85	223.19	3.01
Per cent. digested,	90.08	210.29	49.64	99.91	90.24	74.88

Sheep II.

Amount consumed as above,	679.95	25.00	42.04	165.22	435.53	12.16
Minus 234.41 grams feces excreted,	221.52	16.59	24.72	60.54	112.43	7.24
Amount digested,	458.43	8.41	17.32	104.68	323.10	4.92
Minus hay digested,	214.45	4.90	13.02	73.98	118.57	3.09
Corn bran digested,	243.98	3.51	4.30	30.70	204.53	1.83
Per cent. digested,	77.09	129.04	26.03	66.90	82.70	45.52
Average per cent. digested,	83.59	169.67	37.84	83.41	86.47	60.20

SERIES XIX., GLUTEN FEED, PERIOD 14.

Sheep V.

650 grams English hay fed,	584.68	35.14	48.47	184.47	300.93	15.67
150 grams gluten feed fed,	135.78	1.29	37.92	12.65	77.21	6.71
Amount consumed,	720.46	36.43	86.39	197.12	378.14	22.38
Minus 237.30 grams feces excreted,	223.20	20.47	29.04	58.17	105.94	9.58
Amount digested,	497.26	15.96	57.35	138.95	272.20	12.80
Minus hay digested,	344.96	11.60	25.20	112.53	186.58	8.78
Gluten feed digested,	152.30	4.36	32.15	26.42	85.62	4.02
Per cent. digested,	112.09	337.98	84.78	208.85	110.89	59.91

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XIX., GLUTEN FEED, PERIOD 14 — *Concluded.*

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	720.46	36.43	86.39	197.12	378.14	22.38
Minus 262.21 grams feces excreted,	247.05	21.49	27.18	69.87	118.50	10.01
Amount digested,	473.41	14.94	59.21	127.25	259.64	12.37
Minus hay digested,	344.96	11.60	25.20	112.53	186.58	8.78
Gluten feed digested,	128.45	3.34	34.01	14.72	73.06	3.59
Per cent. digested,	94.54	258.91	89.69	116.36	94.63	53.50
Average per cent. digested,	103.32	298.45	87.24	162.61	102.76	56.71

SERIES XIX., ENGLISH HAY AND GLUTEN FEED, — GLUTEN FEED, PERIOD 15.

Sheep V.

650 grams English hay fed,	587.73	33.62	44.26	185.02	311.90	12.93
125 grams gluten feed fed,	113.59	2.61	29.35	9.28	66.97	5.38
Amount consumed,	701.32	36.23	73.61	194.30	378.87	18.31
Minus 246.94 grams feces excreted,	233.51	20.88	26.34	65.36	112.55	8.38
Amount digested,	467.81	15.35	47.27	128.94	266.32	9.93
Minus hay digested,	346.76	11.09	23.02	112.86	193.38	7.24
Gluten feed digested,	121.05	4.26	24.25	16.08	72.94	2.69
Per cent. ration digested,	66.70	42.45	64.22	66.36	70.29	54.23
Per cent. gluten feed digested,	106.57	163.22	82.62	173.28	108.91	50.00

Sheep VI.

Amount consumed as above,	701.32	36.23	73.61	194.30	378.87	18.31
Minus 280.06 grams feces excreted,	264.94	21.75	29.67	77.04	127.00	9.48
Amount digested,	436.38	14.48	43.94	117.26	251.87	8.83
Minus hay digested,	346.76	11.09	23.02	112.86	193.38	7.24
Gluten feed digested,	89.62	3.39	20.92	4.40	58.49	1.59
Per cent. ration digested,	62.22	39.97	59.69	60.35	66.48	48.23
Per cent. gluten feed digested,	78.90	129.89	71.28	47.41	87.34	29.55
Average per cent. ration digested,	64.46	41.21	61.96	63.36	68.39	51.23
Average per cent. gluten feed digested,	92.74	146.56	76.95	110.35	98.13	39.78

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XX., ENGLISH HAY, PERIOD 1.

Sheep I.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	737.36	44.32	53.24	239.13	381.94	18.73
Minus 281.27 grams feces excreted,	260.32	26.73	26.16	70.75	126.89	9.79
English hay digested,	477.04	17.59	27.08	168.38	255.05	8.94
Per cent. digested,	64.70	39.69	50.86	70.41	66.78	48.67

Sheep II.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	737.36	44.32	53.24	239.13	381.94	18.73
Minus 291.37 grams feces excreted,	269.63	27.93	26.42	75.74	129.62	9.92
English hay digested,	467.73	16.39	26.82	163.39	252.32	8.81
Per cent. digested,	63.43	36.98	50.38	68.33	66.06	47.96
Average per cent. digested,	64.07	38.34	50.62	69.62	66.42	48.32

SERIES XX., PUMPKINS (ENTIRE), PERIOD 2.

Sheep I.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
500 grams English hay fed,	449.50	27.96	30.66	145.10	231.62	14.16
2,000 grams pumpkins fed,	268.40	20.94	38.03	34.92	145.63	28.88
Amount consumed,	717.90	48.90	68.69	180.02	377.25	43.04
Minus 223.14 grams feces excreted,	211.14	23.42	27.03	57.13	93.09	10.47
Amount digested,	506.76	25.48	41.66	122.89	284.16	32.57
Minus hay digested,	287.68	10.62	15.84	100.12	152.87	6.79
Pumpkins digested,	219.08	14.86	25.82	22.77	131.29	25.78
Per cent. digested,	81.62	70.96	67.89	65.20	90.84	89.27

Sheep II.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	717.90	48.90	68.69	180.02	377.25	43.04
Minus 203.70 grams feces excreted,	193.41	25.09	23.87	50.71	83.99	9.75
Amount digested,	524.49	23.81	44.82	129.31	293.26	33.29
Minus hay digested,	287.68	10.62	15.84	100.12	152.87	6.79
Pumpkins digested,	236.81	13.19	28.98	29.19	140.39	26.50
Per cent. digested,	88.23	62.99	76.20	83.59	96.40	91.76
Average per cent. digested,	84.93	66.98	72.05	74.39	93.62	90.52

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XX., PUMPKINS (ENTIRE), PERIOD 3.

Sheep I.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	495.00	30.15	36.23	159.09	256.96	12.57
150 grams gluten feed fed,	136.65	2.51	34.91	11.30	81.58	6.35
1,200 grams pumpkins fed,	191.04	13.87	29.94	27.49	98.90	20.84
Amount consumed,	822.69	46.53	101.08	197.88	437.44	39.76
Minus 248.90 grams feces excreted,	236.31	25.62	30.51	62.06	108.34	9.78
Amount digested,	586.38	20.91	70.57	135.82	329.10	29.98
Minus hay and gluten feed digested,	435.84	11.43	45.53	122.68	243.75	11.62
Pumpkins digested,	150.54	9.48	25.04	13.14	85.35	18.36
Per cent. digested,	78.80	68.35	83.63	47.80	86.30	88.10

Sheep II.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	822.69	46.53	101.08	197.88	437.44	39.76
Minus 255.64 grams feces excreted,	242.78	28.19	30.83	62.49	110.78	10.49
Amount digested,	579.91	18.34	70.25	135.39	326.66	29.27
Minus hay and gluten feed digested,	435.84	11.43	45.53	122.68	243.75	11.62
Pumpkins digested,	144.07	6.91	24.72	12.71	82.91	17.65
Per cent. digested,	75.41	49.82	82.57	46.23	83.83	84.69
Average per cent. digested,	77.11	59.09	83.10	47.02	85.07	86.40

SERIES XX., PUMPKINS (ENTIRE), PERIOD 4.

Sheep I.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
412 grams English hay fed,	373.07	22.72	27.42	120.99	190.86	11.08
112 grams gluten feed fed,	102.73	2.09	26.56	8.49	60.82	4.77
2,000 grams pumpkins fed,	234.40	19.48	34.81	36.87	113.24	30.00
Amount consumed,	710.20	44.29	88.79	166.35	364.92	45.85
Minus 216.87 grams feces excreted,	204.77	20.62	28.20	58.93	88.79	8.23
Amount digested,	505.43	23.67	60.59	107.42	276.13	37.62
Minus hay and gluten feed digested,	328.30	8.68	34.55	93.23	181.21	9.35
Pumpkins digested,	177.13	14.99	26.04	14.19	94.92	28.27
Per cent. digested,	75.57	76.95	74.81	38.49	83.82	94.23

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XX., ENGLISH HAY AND GLUTEN FEED, — GLUTEN FEED, PERIOD 5.

Sheep I.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	497.86	29.92	43.21	159.22	251.62	13.89
150 grams gluten feed fed,	136.71	2.67	36.54	11.39	79.82	6.29
Amount consumed,	634.57	32.59	79.75	170.61	331.44	20.18
Minus 197.54 grams feces excreted,	188.22	19.20	26.76	44.16	90.14	7.96
Amount digested,	446.35	13.39	52.99	126.45	241.30	12.22
Minus hay digested,	318.63	11.37	22.04	109.86	166.07	6.71
Gluten feed digested,	127.72	2.02	30.95	16.59	75.23	5.51
Per cent. ration digested,	70.34	41.09	66.45	74.12	72.80	60.56
Per cent. gluten feed digested,	93.42	75.66	84.70	145.65	94.25	87.60

Sheep II.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	634.57	32.59	79.75	170.61	331.44	20.18
Minus 221.18 grams feces excreted,	211.36	23.19	30.77	51.87	97.12	8.41
Amount digested,	423.21	9.40	48.98	118.74	234.32	11.77
Minus hay digested,	318.63	11.37	22.04	109.86	166.07	6.71
Gluten feed digested,	104.58	–	26.94	8.88	68.25	5.06
Per cent. ration digested,	66.69	28.84	61.42	69.60	70.70	58.33
Per cent. gluten feed digested,	76.50	–	73.73	77.96	85.50	80.45
Average per cent. ration digested,	68.52	34.97	63.94	71.86	71.75	59.45
Average per cent. gluten feed digested,	84.96	75.66[1]	79.22	111.81	89.88	84.03

SERIES XX., ENGLISH HAY, PERIOD 6.

Sheep IV.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	717.84	44.22	53.41	230.28	272.99	16.94
Minus 300.50 grams feces excreted,	288.33	25.63	27.59	84.97	139.85	10.29
Amount digested,	429.51	18.59	25.82	145.31	233.14	6.65
Per cent. digested,	60.08	42.04	48.34	63.10	62.51	39.26

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[1] One sheep only.

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XX., SOY BEAN HAY, PERIOD 7.

Sheep V.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
400 grams English hay fed,	367.68	22.39	26.95	120.19	189.51	8.64
Minus 29.03 grams waste,	27.24	1.64	1.74	9.57	13.86	.43
Amount consumed,	340.44	20.75	25.21	110.62	175.65	8.21
400 grams soy bean hay fed,	353.08	23.41	56.00	123.15	143.21	7.31
Minus 55.1 grams waste,	51.00	2.77	3.76	22.93	21.13	.41
Amount soy bean hay fed,	302.08	20.64	52.24	100.22	122.08	6.90
Amount consumed,	642.52	41.39	77.45	210.84	297.73	15.11
Minus 284.68 grams feces excreted,	270.13	30.69	27.80	87.25	116.69	7.70
Amount digested,	372.39	10.70	49.65	123.59	181.04	7.41
Minus hay digested,	214.48	8.30	12.61	74.12	114.17	3.69
Amount soy bean hay digested,	157.91	2.40	37.04	49.47	66.87	3.72
Per cent. digested,	52.27	11.63	70.90	49.36	54.78	53.91

Sheep VI.

400 grams English hay fed,	367.68	22.39	26.95	120.19	189.51	8.64
400 grams soy bean hay fed,	353.08	23.41	56.00	123.15	143.21	7.31
Amount consumed,	720.76	45.80	82.95	243.34	332.72	15.95
Minus 287.90 grams feces excreted,	273.65	29.99	25.31	94.16	116.86	7.33
Amount digested,	447.11	15.81	57.64	149.18	215.86	8.62
Minus hay digested,	231.64	8.96	13.48	80.53	123.18	3.89
Soy bean hay digested,	215.47	6.85	44.16	68.65	92.68	4.73
Per cent. digested,	61.03	29.26	78.86	55.75	64.72	64.71
Average per cent. digested,	56.65	20.45	74.88	52.56	59.75	59.31

SERIES XX., CARROTS, PERIOD 8.

Sheep IV.

500 grams English hay fed,	449.85	30.23	35.72	146.34	225.95	11.61
1,500 grams carrots fed,	196.95	20.31	22.12	17.39	135.12	2.01
Amount consumed,	646.80	50.54	57.84	163.73	361.07	13.62
Minus 228.61 grams feces excreted,	216.81	28.25	22.79	58.69	98.39	8.69
Amount digested,	429.99	22.29	35.05	105.04	262.68	4.93
Minus hay digested,	283.41	12.09	17.86	98.05	146.87	5.22
Carrots digested,	146.58	10.20	17.19	6.99	115.81	–
Per cent. digested,	74.42	50.22	77.71	40.19	85.71	–

Table V. — Computation of Digestion Coefficients — *Continued.*

Series XX., Carrots, Period 8 — *Concluded.*

Sheep V.

Item.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	646.80	50.54	57.84	163.73	361.07	13.62
Minus 200.63 grams feces excreted,	190.44	25.27	21.10	47.95	88.24	7.88
Amount digested,	456.36	25.27	36.74	115.78	272.83	5.74
Minus hay digested,	283.41	12.09	17.86	98.05	146.87	5.22
Carrots digested,	172.95	13.18	18.88	17.73	125.96	.52
Per cent. digested,	87.81	64.89	85.35	101.96	93.22	25.87

Sheep VI.

Item.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	646.80	50.54	57.84	163.73	361.07	13.62
Minus 208.06 grams feces excreted,	198.49	29.56	20.84	51.41	88.48	8.20
Amount digested,	448.31	20.98	37.00	112.32	272.59	5.42
Minus hay digested,	283.41	12.09	17.86	98.05	146.87	5.22
Carrots digested,	164.90	8.89	19.14	14.27	125.72	.20
Per cent. digested,	83.73	43.77	86.53	82.06	93.04	9.95
Average per cent. digested,	81.99	52.96	83.20	74.74	90.66	17.91[1]

Series XX., Carrots, Period 9.

Sheep IV.

Item.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	497.04	30.97	37.78	151.30	263.72	13.27
150 grams gluten feed fed,	137.03	3.04	36.41	10.63	80.36	6.59
1,000 grams carrots fed,	114.00	11.18	12.67	9.69	79.22	1.24
Amount consumed,	748.07	45.19	86.86	171.62	423.30	21.10
Minus 250.91 grams feces excreted,	240.07	27.03	28.28	59.30	116.31	9.15
Amount digested,	508.00	18.16	58.58	112.32	306.99	11.95
Minus hay and gluten feed digested,	393.12	9.86	47.48	103.64	223.65	9.93
Carrots digested,	114.88	8.30	11.10	8.68	83.34	2.02
Per cent. digested,	100.70	74.24	87.61	89.58	105.20	162.90

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[1] Two sheep only.

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XX., CARROTS, PERIOD 9 — *Concluded.*

Sheep V.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	748.07	45.19	86.86	171.62	423.30	21.10
Minus 233.76 grams feces excreted,	222.94	25.06	25.95	53.57	109.73	8.63
Amount digested,	525.13	20.13	60.91	118.05	313.57	12.47
Minus hay and gluten feed digested,	393.12	9.86	47.48	103.64	223.65	9.93
Carrots digested,	132.01	10.27	13.43	14.41	89.92	2.54
Per cent. digested,	115.80	91.86	106.00	148.71	113.51	204.84

Sheep VI.

Amount consumed as above,	748.07	45.19	86.86	171.62	423.30	21.10
Minus 210.84 grams feces excreted,	200.99	24.58	23.17	48.84	96.06	8.34
Amount digested,	547.08	20.61	63.69	122.78	327.24	12.76
Minus hay and gluten feed digested,	393.12	9.86	47.48	103.64	223.65	9.93
Carrots digested,	153.96	10.75	16.21	19.14	103.59	2.83
Per cent. digested,	135.05	96.15	127.94	197.52	130.76	228.23
Average per cent. digested,	113.85	87.42	107.18	145.27	116.49	198.66

SERIES XX., ENGLISH HAY, PERIOD 10.

Sheep VII.

600 grams English hay fed,	546.00	35.65	44.50	174.83	277.37	13.65
Minus 244.84 grams feces excreted,	235.85	20.42	21.25	70.68	115.74	7.76
Amount digested,	310.15	15.23	23.25	104.15	161.63	5.89
Per cent. digested,	56.80	42.72	52.25	59.57	58.27	43.15

Sheep VIII.

600 grams English hay fed,	546.00	35.65	44.50	174.83	277.37	13.65
Minus 228.90 grams feces excreted,	220.06	19.89	21.04	65.67	105.52	7.94
Amount digested,	325.94	15.76	23.46	109.16	171.85	5.71
Per cent. digested,	59.70	44.21	52.72	62.44	61.96	41.83
Average per cent. digested,	58.25	43.47	52.49	61.01	60.12	42.49

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XX., NEW BEDFORD PIG MEAL, PERIOD 11.

Sheep IV.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	455.35	30.96	39.02	146.35	227.64	11.38
150 grams gluten feed fed,	137.18	2.96	34.94	11.48	81.46	6.34
200 grams New Bedford pig meal fed,	182.40	35.84	43.03	16.69	80.80	6.04
Amount consumed,	774.93	69.76	116.99	174.52	389.90	23.76
Minus 295.87 grams feces excreted,	281.73	42.71	40.68	70.43	121.09	6.82
Amount digested,	493.20	27.05	76.31	104.09	268.81	16.94
Minus hay and gluten feed digested,	367.37	9.84	47.33	101.01	200.92	8.86
New Bedford pig meal digested,	125.83	17.21	28.98	3.08	67.89	8.08
Per cent. digested,	68.99	48.02	67.35	18.45	84.02	133.77

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	774.93	69.76	116.99	174.52	389.90	23.76
Minus 295.20 grams feces excreted,	281.18	45.24	38.94	69.14	121.59	6.27
Amount digested,	493.75	24.52	78.05	105.38	268.31	17.49
Minus hay and gluten feed digested,	367.37	9.84	47.33	101.01	200.92	8.86
New Bedford pig meal digested,	126.38	14.68	30.72	4.37	67.39	8.63
Per cent. digested,	69.29	40.96	71.39	26.18	83.40	142.88
Average per cent. digested,	69.14	44.49	69.37	22.32	83.71	138.33

SERIES XX., ENGLISH HAY AND WHEAT GLUTEN FLOUR, PERIOD 12.[1]

Sheep VII.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	554.70	37.00	39.77	173.73	289.00	15.20
40 grams wheat gluten fed,	36.66	.32	33.88	.04	2.28	.14
Amount consumed,	591.36	37.32	73.65	173.77	291.28	15.34
Minus 238.80 grams feces excreted,	227.70	19.17	22.72	66.08	111.53	8.20
Amount digested,	363.66	18.15	50.93	107.69	179.75	7.14
Minus wheat gluten (assumed to be all digested).	36.66	.32	33.88	.04	2.28	.14
Hay digested,	327.00	17.83	17.05	107.65	177.47	7.00
Per cent. digested,	58.95	48.19	42.87	61.96	61.44	46.05

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[1] To note effect of wheat gluten flour.

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XX., ENGLISH HAY AND WHEAT GLUTEN FLOUR, PERIOD 12 — *Concluded.*

Sheep VIII.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, ...	591.36	37.32	73.65	173.77	291.38	15.34
Minus 235.59 grams feces excreted, . .	224.59	19.81	23.96	62.80	110.11	7.91
Amount digested, ...	366.77	17.51	49.69	110.97	181.17	7.43
Minus wheat gluten (assumed to be all digested).	36.66	.32	33.88	.04	2.28	.14
Hay digested, ...	330.11	17.19	15.81	110.93	178.89	7.29
Per cent. digested, ...	59.51	46.46	39.75	63.85	61.90	47.96
Average per cent. digested, . . .	59.23	47.33	41.31	62.91	61.99	47.01

SERIES XX., VEGETABLE IVORY MEAL, PERIOD 13.

Sheep IV.

500 grams English hay fed, ...	460.10	29.45	33.59	148.24	237.46	11.36
150 grams gluten feed fed, ...	137.70	2.96	35.58	11.31	81.72	6.13
200 grams vegetable ivory meal fed, . .	182.50	2.17	8.61	15.09	155.22	1.41
Amount consumed, ...	780.30	34.58	77.78	174.64	474.40	18.90
Minus 263.03 grams feces excreted, . .	248.69	23.80	32.60	61.05	121.64	9.60
Amount digested, ...	531.61	10.78	45.18	113.59	352.76	9.30
Minus hay and gluten feed digested, . .	370.64	9.40	44.27	102.11	207.47	8.75
Vegetable ivory meal digested, . . .	160.97	1.38	.91	11.48	145.28	.55
Per cent. digested, ...	88.20	63.59	10.57	76.08	93.60	39.01

Sheep V.

Amount consumed as above, ...	780.30	34.58	77.78	174.64	474.40	18.90
Minus 242.74 grams feces excreted, . .	229.05	23.14	30.53	54.35	111.73	9.30
Amount digested, ...	551.25	11.44	47.25	120.29	362.67	9.60
Minus hay and gluten feed digested, . .	370.64	9.40	44.27	102.11	207.47	8.75
Vegetable ivory meal digested, . . .	180.61	2.04	2.98	18.18	155.20	.85
Per cent. digested, ...	98.96	94.01	34.61	120.48	99.99	60.28

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XX., VEGETABLE IVORY MEAL, PERIOD 13 — *Concluded.*

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	780.30	34.58	77.78	174.64	474.40	18.90
Minus 237.89 grams feces excreted,	224.04	24.22	28.92	53.03	108.17	9.70
Amount digested,	556.26	10.36	48.86	121.61	366.23	9.20
Minus hay and gluten feed digested,	370.64	9.40	44.27	102.11	207.47	8.75
Vegetable ivory meal digested,	185.62	.96	3.59	19.50	158.76	.45
Per cent. digested,	101.71	44.24	41.70	129.22	102.28	31.91
Average per cent. digested,	96.29	67.28	28.96	108.59	98.62	43.73

SERIES XX., ENGLISH HAY AND GLUTEN FEED, — GLUTEN FEED, PERIOD 14.

Sheep IV.

550 grams English hay fed,	509.41	31.94	35.40	165.25	263.63	13.19
150 grams gluten feed fed,	138.14	2.94	37.45	11.81	79.74	6.20
Amount consumed,	647.55	34.88	72.85	177.06	343.37	19.39
Minus 271 grams feces excreted,	257.02	25.42	26.63	70.22	125.24	9.51
Amount digested,	390.53	9.46	46.22	106.84	218.13	9.88
Minus hay digested,	320.93	12.78	17.70	110.72	171.36	5.94
Gluten feed digested,	69.60	–	28.52	–	46.77	3.94
Per cent. ration digested,	60.31	27.12	63.45	60.34	63.53	50.95
Per cent. gluten feed digested,	50.38	–	76.15	–	58.65	63.55

Sheep V.

Amount consumed as above,	647.55	34.88	72.85	177.06	343.37	19.39
Minus 250.96 grams feces excreted,	238.11	24.76	26.22	60.22	116.58	10.33
Amount digested,	409.44	10.12	46.63	116.84	226.79	9.06
Minus hay digested,	320.93	12.78	17.70	110.72	171.36	5.94
Gluten feed digested,	88.51	–	28.93	6.12	55.43	3.12
Per cent. ration digested,	63.23	29.01	64.01	65.99	66.05	46.73
Per cent. gluten feed digested,	64.07	–	77.25	51.82	69.51	50.32

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XX., ENGLISH HAY AND GLUTEN FEED, — GLUTEN FEED, — PERIOD 14 — *Concluded.*

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	647.55	34.88	72.85	177.06	343.37	19.39
Minus 246.79 grams feces excreted,	234.80	23.74	25.71	60.34	115.69	9.32
Amount digested,	412.75	11.14	47.14	116.72	227.68	10.07
Minus hay digested,	320.93	12.78	17.70	110.72	171.36	5.94
Gluten feed digested,	91.82	-	29.44	6.00	56.32	4.13
Per cent. ration digested,	63.74	31.94	64.71	65.92	66.31	51.93
Per cent. gluten feed digested,	66.47	-	78.61	50.80	70.63	66.01
Average per cent. ration digested,	62.43	29.36	64.06	64.08	65.30	49.87
Average per cent. gluten feed digested,	60.31	-	77.34	51.31[1]	66.26	60.16

SERIES XXI., ENGLISH HAY AND GLUTEN FEED, — GLUTEN FEED, PERIOD 1.

Sheep IV.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	491.43	33.96	37.10	157.55	248.91	13.91
150 grams gluten feed fed,	135.48	4.55	38.33	10.07	80.08	2.45
Amount consumed,	626.91	38.51	75.43	167.62	328.99	16.36
Minus 236.19 grams feces excreted,	219.61	26.27	23.85	57.80	102.86	8.83
Amount digested,	407.30	12.24	51.58	109.82	226.13	7.53
Minus hay digested,	280.12	12.90	15.95	96.11	149.35	5.98
Gluten feed digested,	127.18	-	35.63	13.71	76.78	1.55
Per cent. ration digested,	64.97	31.78	68.38	65.52	68.73	46.03
Per cent. gluten feed digested,	93.87	-	92.96	136.00	95.88	63.27

Sheep V.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams minus 1.86 grams waste equals 548.14 grams English hay fed.	489.76	33.84	36.98	157.02	248.06	13.86
150 grams gluten feed fed,	135.48	4.55	38.33	10.07	80.08	2.45
Amount consumed,	625.24	38.39	75.31	167.09	328.14	16.31
Minus 222.51 grams feces excreted,	206.82	29.24	23.70	52.64	92.72	8.52
Amount digested,	418.42	9.15	51.61	114.45	235.42	7.79
Minus hay digested,	279.16	12.86	15.90	95.78	148.84	5.96
Gluten feed digested,	139.26	-	35.71	18.67	86.58	1.83
Per cent. ration digested,	66.92	23.83	68.53	68.50	71.74	47.76
Per cent. gluten feed digested,	102.79	-	93.16	185.00	108.12	74.69

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[1] Two sheep only.

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXI., ENGLISH HAY AND GLUTEN FEED, — GLUTEN FEED, — PERIOD 1 — *Concluded.*

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as for Sheep IV.,	626.91	38.51	75.43	167.62	328.99	16.36
Minus 211.77 grams feces excreted,	195.55	25.99	22.37	48.50	90.38	8.31
Amount digested,	431.36	12.52	53.06	119.12	238.61	8.05
Minus hay digested,	280.12	12.90	15.95	96.11	149.35	5.98
Gluten feed digested,	151.24	-	37.11	23.01	89.26	2.07
Per cent. ration digested,	68.81	32.51	70.34	71.07	72.53	49.21
Per cent. gluten feed digested,	111.63	-	96.82	228.00	111.46	84.49
Average per cent. ration digested,	66.90	29.37	69.08	68.36	71.00	47.67
Average per cent. gluten feed digested,	102.76	-	94.31	183.00	105.15	74.15

SERIES XXI., ENGLISH HAY, PERIOD 2.

Sheep VII.

700 grams English hay fed,	623.84	43.11	47.10	200.01	315.97	17.65
Minus 301.12 grams feces excreted,	281.40	30.93	27.32	82.25	130.74	10.16
Amount digested,	342.44	12.18	19.78	117.76	185.23	7.49
Per cent. digested,	54.89	28.25	42.00	58.88	58.62	42.44

Sheep VIII.

700 grams English hay fed,	623.84	43.11	47.10	200.01	315.97	17.65
Minus 256.07 grams feces excreted,	238.91	26.88	25.87	63.88	112.51	9.77
Amount digested,	384.93	16.23	21.33	136.13	203.46	7.88
Per cent. digested,	61.70	37.65	45.08	68.06	64.39	44.65
Average per cent. digested,	58.30	32.95	43.54	63.47	61.51	43.55

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXI., VEGETABLE IVORY MEAL, PERIOD 3.

Sheep IV.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	486.20	32.48	36.51	158.21	245.05	13.95
150 grams gluten feed fed,	135.66	4.73	38.05	9.90	80.55	2.43
200 grams minus 1.86 grams waste equals 198.14 grams vegetable ivory meal fed.	176.54	2.10	9.41	15.45	146.83	2.75
Amount consumed,	798.40	39.31	83.97	183.56	472.43	19.13
Minus 258.16 grams feces excreted,	243.01	24.45	32.37	61.36	115.26	9.57
Amount digested,	555.39	14.86	51.60	122.20	357.17	9.56
Minus hay and gluten feed digested,	416.65	10.79	51.45	114.31	231.18	7.86
Vegetable ivory meal digested,	138.74	4.07	.15	7.89	125.99	1.70
Per cent. digested,	78.59	193.81	1.59	51.07	85.81	61.82
Sheep V.						
550 grams minus .7 gram waste equals 549.3 grams English hay fed.	485.58	32.44	36.47	158.01	244.72	13.94
150 grams gluten feed fed,	135.66	4.73	38.05	9.90	80.55	2.43
200 grams minus 1.43 grams waste equals 198.57 grams vegetable ivory meal fed.	176.93	2.11	9.43	15.48	147.15	2.76
Amount consumed,	798.17	39.28	83.95	183.39	472.42	19.13
Minus 253.24 grams feces excreted,	238.55	33.64	32.08	53.72	109.14	9.97
Amount digested,	559.62	5.64	51.87	129.67	363.28	9.16
Minus hay and gluten feed digested,	416.23	10.78	51.42	114.18	230.94	7.86
Vegetable ivory meal digested,	143.39	–	.45	15.49	132.34	1.30
Per cent. digested,	81.04	–	4.77	100.06	89.94	47.10
Sheep VI.						
550 grams English hay fed,	486.20	32.48	36.51	158.21	245.05	13.95
150 grams gluten feed fed,	135.66	4.73	38.05	9.90	80.55	2.43
200 grams minus 1.57 grams equals 198.43 grams vegetable ivory meal fed.	176.81	2.10	9.42	15.47	147.06	2.76
Amount consumed,	798.67	39.31	83.98	183.58	472.66	19.14
Minus 248.26 grams feces excreted,	233.44	26.61	31.96	58.99	106.22	9.66
Amount digested,	565.23	12.70	52.02	124.59	366.44	9.48
Minus hay and gluten feed digested,	416.65	10.79	51.45	114.31	231.18	7.86
Vegetable ivory meal digested,	148.58	1.91	.57	10.28	135.26	1.62
Per cent. digested,	84.03	90.95	6.04	66.45	91.98	58.70
Average per cent. digested,	81.22	142.38[1]	4.13	72.53	89.24	55.87

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[1] Two sheep only.

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXI., ENGLISH HAY AND WHEAT GLUTEN FLOUR, PERIOD 4.[1]

Sheep VII.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
700 grams English hay fed,	621.95	40.99	47.21	203.19	312.77	17.79
40 grams wheat gluten fed,	37.18	.29	34.51	.03	2.20	.15
Amount consumed,	659.13	41.28	81.72	203.22	314.97	17.94
Minus 293.60 grams feces excreted,	278.48	26.20	25.84	84.71	131.70	10.03
Amount digested,	380.65	15.08	55.88	118.51	183.27	7.91
Minus 40 grams wheat gluten (assumed to be all digested).	37.18	.29	34.51	.03	2.20	.15
English hay digested,	343.47	14.79	21.37	118.48	181.07	7.76
Per cent. digested,	55.22	36.08	45.27	58.31	57.89	43.62

SERIES XXI., ENGLISH HAY, POTATO STARCH AND GLUTEN MEAL (DIAMOND), — GLUTEN MEAL (DIAMOND), PERIOD 5.

Sheep IV.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
300 grams English hay fed,	269.61	18.52	20.03	91.05	132.95	7.06
125 grams potato starch fed,	111.95	–	–	–	111.95	–
100 grams gluten meal (Diamond) fed,	90.97	1.03	41.06	1.87	45.46	1.55
Amount consumed,	472.53	19.55	61.09	92.92	290.36	8.61
Minus 135.77 grams feces excreted,	126.67	15.76	17.64	33.21	56.23	5.83
Amount digested,	343.86	3.79	43.45	59.71	234.13	2.78
Minus hay and starch (100 per cent.) digested,	265.62	6.85	8.61	55.54	191.72	3.03
Gluten meal (Diamond) digested,	78.24	–	34.84	4.17	42.41	–
Per cent. ration digested,	72.77	19.38	71.12	64.26	80.63	32.29
Per cent. gluten meal (Diamond) digested,	86.00	–	84.80	–	93.30	–

Sheep V.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	472.53	19.55	61.09	92.92	290.36	8.61
Minus 113.25 grams feces excreted,	107.36	17.71	15.07	23.48	46.02	5.08
Amount digested,	365.17	1.84	46.02	69.44	244.34	3.53
Minus hay and starch (100 per cent.) digested,	265.62	6.85	8.61	55.54	191.72	3.03
Gluten meal (Diamond) digested,	99.55	–	37.41	13.90	52.62	.50
Per cent. ration digested,	77.28	9.41	75.33	74.73	84.15	41.00
Per cent. gluten meal (Diamond) digested,	109.40	–	91.20	–	120.10	32.25

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[1] To note effect of wheat gluten flour.

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXI., ENGLISH HAY, POTATO STARCH AND GLUTEN MEAL (DIAMOND), — GLUTEN MEAL (DIAMOND), PERIOD 5 — *Concluded.*

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	472.53	19.55	61.09	92.92	290.36	8.61
Minus 132.14 grams feces excreted,	125.27	16.95	17.15	31.17	54.46	5.54
Amount digested,	347.26	2.60	43.94	61.75	235.90	3.07
Minus hay and starch (100 per cent.) digested,	265.62	6.85	8.61	55.54	191.72	3.03
Gluten meal (Diamond) digested,	81.64	-	35.33	6.21	44.18	-
Per cent. ration digested,	73.49	13.30	71.93	66.46	81.24	35.66
Per cent. gluten meal (Diamond) digested,	89.70	-	86.00	-	97.20	-
Average per cent. ration digested,	74.51	14.03	72.79	68.48	82.01	36.32
Average per cent. gluten meal (Diamond) digested.	95.03	-	87.33	-	70.20	32.25[1]

SERIES XXI., DISTILLERS' GRAINS, PERIOD 6.

Sheep IV.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
300 grams English hay fed,	269.25	17.91	20.11	89.42	135.32	6.49
125 grams potato starch fed,	112.84	-	-	-	112.84	-
100 grams gluten meal (Diamond) fed,	91.06	1.06	41.09	2.03	45.17	1.71
200 grams distillers' grains fed,	193.74	4.48	51.15	28.50	91.40	18.21
Amount consumed,	666.89	23.45	112.35	119.95	384.73	26.41
Minus 196.28 grams feces excreted,	186.29	17.90	28.15	45.25	86.46	8.53
Amount digested,	480.60	5.55	84.20	74.70	298.27	17.88
Minus basal ration digested,	354.86	2.66	44.68	62.19	240.53	2.95
Distillers' grains digested,	125.74	2.89	39.52	12.51	57.74	14.93
Per cent. digested,	64.88	64.51	77.26	43.89	63.17	81.99

Sheep V.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	666.89	23.45	112.35	119.95	384.73	26.41
Minus 190.84 grams feces excreted,	181.18	19.84	29.70	39.90	83.30	8.44
Amount digested,	485.71	3.61	82.65	80.05	301.43	17.97
Minus basal ration digested,	354.86	2.66	44.68	62.19	240.53	2.95
Distillers' grains digested,	130.85	.95	37.97	17.86	60.90	15.02
Per cent. digested,	67.54	21.21	74.23	62.67	66.63	82.48

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[1] One sheep only.

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXI., DISTILLERS' GRAINS, PERIOD 6 — *Concluded.*

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	666.89	23.45	112.35	119.95	384.73	26.41
Minus 189.96 grams feces excreted,	180.41	19.75	28.16	42.09	80.99	9.42
Amount digested,	486.48	3.70	84.19	77.86	303.74	16.99
Minus basal ration digested,	354.86	2.66	44.68	62.19	240.53	2.95
Distillers' grains digested,	131.62	1.04	39.51	15.67	63.21	14.04
Per cent. digested,	67.94	23.21	77.24	54.98	69.16	77.10
Average per cent. digested,	66.79	36.31	76.24	53.85	66.32	80.52

SERIES XXI., CORN BRAN, PERIOD 7.

Sheep IV.

300 grams English hay fed,	271.41	18.40	19.24	87.20	140.06	6.51
125 grams potato starch fed,	109.78	-	-	-	109.78	-
100 grams gluten meal fed,	91.55	.88	40.81	1.85	46.50	1.51
200 grams corn bran fed,	180.48	2.35	15.38	23.84	134.49	4.42
Amount consumed,	653.22	21.63	75.43	112.89	430.83	12.44
Minus 164.70 grams feces excreted,	157.47	14.74	22.55	36.25	77.19	6.74
Amount digested,	495.75	6.89	52.88	76.64	353.64	5.70
Minus basal ration digested,	354.56	2.70	43.84	60.55	243.00	2.89
Corn bran digested,	141.19	4.19	9.04	16.09	110.64	2.81
Per cent. digested,	78.23	178.29	58.78	67.49	82.27	63.57

Sheep V.

Amount consumed as above,	653.22	21.63	75.43	112.89	430.83	12.44
Minus 157.82 grams feces excreted,	150.86	14.92	28.12	29.43	71.72	6.67
Amount digested,	502.36	6.71	47.31	83.46	359.11	5.77
Minus basal ration digested,	354.56	2.70	43.89	60.55	243.00	2.89
Corn bran digested,	147.80	4.01	3.47	22.91	116.11	2.88
Per cent. digested,	81.89	170.63	22.56	96.10	86.33	65.16

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXI., CORN BRAN, PERIOD 7 — *Concluded.*

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	653.22	21.63	75.43	112.89	430.83	12.44
Minus 169.38 grams feces excreted,	162.10	18.75	22.08	40.61	74.58	6.08
Amount digested,	491.12	2.88	53.35	72.28	356.25	6.36
Minus basal ration digested,	354.56	2.70	43.84	60.55	243.00	2.89
Corn bran digested,	136.56	.18	9.51	11.73	113.25	3.47
Per cent. digested,	75.66	7.66	61.83	49.20	84.21	78.51
Average per cent. digested,	78.59	152.19	47.72	70.93	84.27	69.08

SERIES XXI., NEW BEDFORD GARBAGE TANKAGE, PERIOD 8.

Sheep IV.[1]

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	497.86	34.65	36.19	167.93	246.00	13.09
150 grams gluten feed fed,	136.58	4.67	38.05	9.97	81.53	2.36
150 grams New Bedford garbage tankage fed,	137.21	21.57	30.21	13.27	69.87	2.29
Amount consumed,	771.65	60.89	104.45	191.17	397.40	17.74
Minus 286.48 grams feces excreted,	272.18	35.87	42.98	67.58	117.31	8.44
Amount digested,	499.47	25.02	61.47	123.59	280.09	9.30
Minus basal ration digested,	425.07	11.40	51.23	120.97	232.55	7.42
New Bedford garbage tankage digested,	74.40	13.62	10.24	2.62	47.54	1.88
Per cent. digested,	54.22	63.14	33.90	19.74	68.04	82.09

Sheep V.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	497.86	34.65	36.19	167.93	246.00	13.09
Minus 29.28 grams waste hay,	26.36	1.83	1.88	8.76	13.27	.62
English hay consumed,	471.50	32.82	34.31	159.17	232.73	12.47
150 grams gluten feed fed,	136.58	4.67	38.05	9.97	81.53	2.36
150 grams New Bedford garbage tankage fed,	137.21	21.57	30.21	13.27	69.87	2.29
Amount consumed,	745.29	59.06	102.57	182.41	384.13	17.12
Minus 244.60 grams feces excreted,	231.78	32.43	43.57	48.05	100.10	7.63
Amount digested,	513.51	26.63	59.00	134.36	284.03	9.49
Minus basal ration digested,	407.41	10.87	49.93	115.02	223.12	7.12
New Bedford garbage tankage digested,	106.10	15.76	9.07	19.34	60.91	2.37
Per cent. digested,	77.33	73.06	30.02	145.80	87.18	103.48

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[1] Excluded from average.

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXI., NEW BEDFORD GARBAGE TANKAGE, PERIOD 8 — *Concluded.*

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as for Sheep IV.,	771.65	60.89	104.45	191.17	397.40	17.74
Minus 247.68 grams feces excreted,	235.27	33.48	39.57	54.70	100.56	6.96
Amount digested,	536.38	27.41	64.88	136.47	296.84	10.78
Minus basal ration digested,	425.07	11.40	51.23	120.97	232.55	7.42
New Bedford garbage tankage digested,	111.31	16.01	13.65	15.50	64.29	3.36
Per cent. digested,	81.12	74.22	45.18	116.80	92.01	147.00
Average per cent. digested,	79.22	73.64	37.60	131.30	89.60	125.24

SERIES XXI., ENGLISH HAY, PERIOD 9.

Sheep IX.

600 grams English hay fed,	533.40	37.66	39.95	172.66	268.89	14.24
Minus 14.24 grams waste,	14.01	1.29	.90	4.64	6.87	.31
Amount consumed,	519.39	36.37	39.05	168.02	262.02	13.93
Minus 228.28 grams feces excreted,	217.07	21.73	22.58	62.75	102.56	7.45
English hay digested,	302.32	14.64	16.47	105.27	159.46	6.48
Per cent. digested,	58.21	40.25	42.18	62.65	60.86	46.52

Sheep X.

600 grams English hay fed,	533.40	37.66	39.95	172.66	268.89	14.24
Minus 244.22 grams feces excreted,	232.72	21.29	21.25	70.17	111.59	8.42
English hay digested,	300.68	16.37	18.70	102.49	157.30	5.82
Per cent. digested,	56.37	43.47	46.81	59.36	58.50	40.87

Sheep XI.

600 grams English hay fed,	533.40	37.66	39.95	172.66	268.89	14.24
Minus 2.43 grams waste,	2.36	.27	.09	.85	1.12	.03
English hay consumed,	531.04	37.39	39.86	171.81	267.77	14.21
Minus 257.55 grams feces excreted,	245.24	23.13	23.89	74.80	114.79	8.63
English hay digested,	285.80	14.26	15.97	97.01	152.98	5.58
Per cent. digested,	53.82	38.14	40.07	56.46	57.13	39.27
Average per cent. digested,	56.13	40.62	43.02	59.49	58.83	42.22

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXI., ENGLISH HAY AND WHEAT GLUTEN FLOUR, PERIOD 10.[1]

Sheep IV.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	714.96	49.55	52.26	235.29	359.20	18.66
Minus 60.57 grams waste,	60.57	4.20	4.43	19.93	30.43	1.58
English hay consumed,	654.39	45.35	47.83	215.36	328.77	17.08
50 grams wheat gluten fed,	47.48	.42	42.35	.04	3.88	.79
Minus 34.71 grams waste,	34.71	.31	30.95	.03	2.84	.58
Wheat gluten consumed,	12.77	.11	11.40	.01	1.04	.21
Amount consumed,	667.16	45.46	59.23	215.37	329.81	17.29
Minus 264.12 grams feces excreted,	252.60	24.30	25.51	74.01	118.27	10.51
Amount digested,	414.56	21.16	33.72	141.36	211.54	6.78
Minus wheat gluten digested,	12.77	.11	11.40	.01	1.04	.21
English hay digested,	401.79	21.05	22.32	141.35	210.50	6.57
Per cent. digested,	61.40	46.42	46.67	65.63	64.03	38.47

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	714.96	49.55	52.26	235.29	359.20	18.66
50 grams wheat gluten fed,	47.48	.42	42.35	.04	3.88	.79
Amount consumed,	762.44	49.97	94.61	235.33	363.08	19.45
Minus 288.47 grams feces excreted,	275.89	27.56	28.14	77.17	131.65	11.37
Amount digested,	486.55	22.41	66.47	158.16	231.43	8.08
Minus wheat gluten digested,	47.48	.42	42.35	.04	3.88	.79
English hay digested,	439.07	21.99	24.12	158.12	227.55	7.29
Per cent. digested,	61.41	44.38	46.15	67.20	63.35	39.07
Average per cent. digested,	61.41	45.40	46.41	66.42	63.69	38.77

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[1] To note effect of wheat gluten flour.

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXI., ENGLISH HAY AND GLUTEN FEED, — GLUTEN FEED, PERIOD 11.

Sheep V.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed, ...	499.40	42.65	50.94	152.27	240.01	13.53
150 grams gluten feed fed, ...	137.31	4.63	38.57	10.50	81.10	2.51
Amount consumed, ...	636.71	47.28	89.51	162.77	321.11	16.04
Minus 198.58 grams feces excreted, . .	187.88	28.13	26.55	42.63	82.38	8.19
Amount digested, ...	448.83	19.15	62.96	120.14	238.73	7.85
Minus hay digested, ...	294.65	15.78	27.00	95.93	153.60	6.90
Gluten feed digested, ...	154.18	3.37	35.96	24.21	85.13	.95
Per cent. ration digested, ...	70.49	40.50	70.34	73.81	74.35	48.94
Per cent. gluten feed digested, . . .	112.30	73.00	93.20	231.00	105.00	38.00

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, ...	636.71	47.28	89.51	162.77	321.11	16.04
Minus 193.37 grams feces excreted, . .	183.55	30.78	25.79	39.61	79.50	7.87
Amount digested, ...	453.16	16.50	63.72	123.16	241.61	8.17
Minus hay digested, ...	294.65	15.78	27.00	95.93	153.60	6.90
Gluten feed digested, ...	158.51	.72	36.72	27.23	88.01	1.27
Per cent. ration digested, ...	71.17	34.90	71.19	75.67	75.24	50.94
Per cent. gluten feed digested, . . .	115.40	15.00	95.10	259.00	108.50	51.00
Average per cent. ration digested, . .	70.83	37.70	70.77	74.74	74.80	49.94
Average per cent. gluten feed digested, .	113.85	44.00	94.15	245.00	106.75	44.50

SERIES XXI., FETERITA, PERIOD 12.

Sheep V.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed, ...	495.94	41.96	47.86	151.61	240.97	13.54
150 grams gluten feed fed, ...	137.25	4.68	38.35	10.14	81.94	2.14
200 grams feterita fed, ...	179.18	3.23	23.71	2.51	143.75	5.98
Amount consumed, ...	812.37	49.87	109.92	164.26	466.66	21.66
Minus 244.74 grams feces excreted, . .	229.57	35.51	35.72	49.56	98.59	10.19
Amount digested, ...	582.80	14.36	74.20	114.70	368.07	11.47
Minus hay and gluten feed digested, . .	449.56	17.72	61.21	121.31	242.18	7.84
Feterita digested, ...	133.24	-	12.99	-	125.89	3.63
Per cent. digested, ...	74.36	-	54.79	-	87.58	60.70

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXI., FETERITA, PERIOD 12 — *Concluded.*

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	812.37	49.87	109.92	164.26	466.66	21.66
Minus 243.61 grams feces excreted,	228.55	32.25	39.63	48.43	97.57	10.67
Amount digested,	583.82	17.62	70.29	115.83	396.09	10.99
Minus hay and gluten feed digested,	449.56	17.72	61.21	121.31	242.18	7.84
Feterita digested,	134.26	–	9.08	–	126.91	3.15
Per cent. digested,	74.93	–	38.30	–	88.29	52.68
Average per cent. digested,	74.65	–	46.55	–	87.94	56.69

SERIES XXI., ENGLISH HAY, PERIOD 13.

Sheep XII.

700 grams English hay fed,	634.55	52.48	57.87	197.09	309.85	17.26
Minus 259.31 grams feces excreted,	243.98	31.96	26.15	68.39	109.38	8.10
English hay digested,	390.57	20.52	31.72	128.70	200.47	9.16
Per cent. digested,	60.69	39.10	54.81	65.30	64.70	53.07

Sheep XIII.

700 grams English hay fed,	634.55	52.48	57.87	197.09	309.85	17.26
Minus 6.43 grams waste,	6.23	.38	.27	2.54	2.98	.06
Amount consumed,	628.32	52.10	57.60	194.55	306.87	17.20
Minus 266.30 grams feces excreted,	250.38	33.40	26.49	72.71	108.97	8.81
English hay digested,	377.94	18.70	31.11	121.84	197.90	8.39
Per cent. digested,	60.15	35.89	54.01	62.63	64.49	48.78

Sheep XIV.

700 grams English hay fed,	634.55	52.48	57.87	197.09	309.85	17.26
Minus 280.22 grams feces excreted,	263.60	33.95	28.42	76.73	115.91	8.59
English hay digested,	370.95	18.53	29.45	120.36	193.94	8.67
Per cent. digested,	57.64	35.31	50.89	61.07	62.59	50.23
Average per cent. digested,	59.49	36.77	53.24	63.00	63.93	50.69

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXI., SWEET CLOVER (GREEN), PERIOD 14.

Sheep IV.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
500 grams English hay fed,	442.15	35.81	39.93	138.13	216.17	12.11
1,600 grams sweet clover,	264.80	25.31	45.89	89.50	96.53	7.57
Amount consumed,	706.95	61.12	85.82	227.63	312.70	19.68
Minus 302.46 grams feces excreted,	274.48	35.74	30.11	86.41	112.50	9.72
Amount digested,	432.47	25.38	55.71	141.22	200.20	9.96
Minus hay digested,	260.87	13.25	21.16	87.02	138.35	6.18
Sweet clover digested,	171.60	12.13	34.55	54.20	61.85	3.78
Per cent. digested,	64.80	47.93	75.29	60.56	64.07	49.91

Sheep VI.

1,600 grams sweet clover fed,	264.80	25.31	45.89	89.50	96.53	7.57
Minus 26.14 grams waste,	24.94	2.27	2.47	11.78	8.11	.31
Sweet clover consumed,	239.86	23.04	43.42	77.72	88.42	7.26
500 grams English hay consumed,	442.15	35.81	39.93	138.13	216.17	12.11
Amount consumed,	682.01	58.85	83.35	215.85	304.59	19.37
Minus 270.07 grams feces excreted,	245.33	34.32	28.07	72.59	100.81	9.54
Amount digested,	436.68	24.53	55.28	143.26	203.78	9.83
Minus hay digested,	260.87	13.25	21.16	87.02	138.35	6.18
Sweet clover digested,	175.81	11.28	34.12	56.24	65.43	3.65
Per cent. digested,	73.30	48.96	78.58	72.36	74.00	50.28
Average per cent. digested,	69.05	48.45	76.94	66.46	69.04	50.10

SERIES XXII., SUDAN GRASS (GREEN, SECOND CROP), PERIOD 1.

Sheep IV.

500 grams English hay fed,	433.50	33.42	39.75	131.31	218.05	10.97
1,600 grams Sudan grass (green, fourth cutting) fed.	367.00	24.44	44.29	104.79	190.67	11.81
Amount consumed,	809.50	57.86	84.04	236.10	408.72	22.78
Minus 316.87 grams feces excreted,	294.78	39.71	35.93	72.78	135.72	10.64
Amount digested,	514.72	18.15	48.11	163.32	273.00	12.14
Minus hay digested,	268.77	9.36	20.27	90.60	143.91	4.52
Sudan grass digested,	245.95	8.79	27.84	72.72	129.09	7.64
Per cent. digested,	65.41	37.97	62.86	69.40	67.70	64.69

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXII., SUDAN GRASS (GREEN, SECOND CROP), PERIOD 1 — *Concluded.*

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	809.50	57.86	84.04	236.10	408.72	22.78
Minus 318.78 grams feces excreted,	295.99	42.56	33.62	72.75	135.68	11.37
Amount digested,	513.51	15.30	50.42	163.35	273.04	11.41
Minus hay digested,	268.77	9.36	20.27	90.60	143.91	4.50
Sudan grass digested,	244.74	5.94	30.15	72.75	129.13	6.91
Per cent. digested,	65.09	24.30	68.07	69.42	67.69	58.51
Average per cent. digested,	65.25	30.14	65.47	69.41	67.70	61.60

SERIES XXII., ENGLISH HAY, PERIOD 2.

Sheep IV.

800 grams English hay fed,	685.36	52.02	59.28	218.84	337.75	17.48
Minus 285.59 grams feces excreted,	265.88	36.77	27.49	70.96	120.34	10.32
English hay digested,	419.48	15.25	31.79	147.88	217.41	7.16
Per cent. digested,	61.21	29.31	53.63	67.57	64.37	40.96

Sheep VI.

Amount consumed as above,	685.36	52.02	59.28	218.84	337.75	17.48
Minus 276.71 grams feces excreted,	256.90	38.18	30.85	65.18	112.32	10.38
English hay digested,	428.46	13.84	28.43	153.66	225.43	7.10
Per cent. digested,	62.52	26.61	47.96	70.21	66.75	40.62
Average per cent. digested,	61.87	27.96	50.80	68.89	65.56	40.79

SERIES XXII., SUDAN GRASS (DRY, SECOND CROP), PERIOD 3.

Sheep IV.

400 grams English hay fed,	353.00	28.45	33.43	107.49	174.63	9.00
500 grams Sudan grass (dry, fourth cutting) fed.	390.60	33.55	53.00	129.99	167.68	6.37
Amount consumed,	743.60	62.00	86.43	237.48	342.31	15.37
Minus 309.29 grams feces excreted,	290.42	38.92	38.57	67.61	135.92	9.41
Amount digested,	453.18	23.08	47.86	169.87	206.39	5.96
Minus hay digested,	218.86	7.96	17.05	74.17	115.26	3.69
Sudan grass digested,	234.32	15.12	30.81	95.70	91.13	2.27
Per cent. digested,	59.99	45.07	58.13	73.62	54.35	35.63

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXII., SUDAN GRASS (DRY, SECOND CROP), PERIOD 3 — *Concluded.*

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, ...	743.60	62.00	86.43	237.48	342.31	15.37
Minus 313.86 grams feces excreted, . .	292.83	40.53	36.84	68.73	137.31	9.43
Amount digested, ...	450.77	21.47	49.59	168.75	205.00	5.94
Minus hay digested, ...	218.86	7.96	17.05	74.17	115.26	3.69
Sudan grass digested, ...	321.91	13.51	32.54	94.58	89.74	2.25
Per cent. digested, ...	59.37	40.27	61.40	72.76	53.52	35.32
Average per cent. digested, . . .	59.68	42.67	59.77	73.19	53.94	35.48

SERIES XXII., SUDAN GRASS (FIRST CROP, THIRD CUTTING), PERIOD 4.

Sheep IX.

700 grams Sudan grass (third cutting, dry) fed.	616.00	45.40	73.24	220.47	268.02	8.87
Minus 270.21 grams feces excreted, . .	258.02	21.11	27.56	74.23	130.04	5.08
Sudan grass digested, ...	357.98	24.29	45.68	146.24	137.98	3.79
Per cent. digested, ...	58.11	53.50	62.37	66.33	51.48	42.73

Sheep XI.

700 grams Sudan grass (third cutting, dry) fed.	616.00	45.40	73.24	220.47	268.02	8.87
Minus 292.87 grams feces excreted, . .	278.93	26.22	30.96	77.60	138.32	5.80
Sudan grass digested, ...	337.07	19.18	42.28	142.87	129.70	3.07
Per cent. digested, ...	54.72	42.25	47.73	64.80	48.39	34.61
Average per cent. digested, . . .	56.42	47.88	60.05	65.57	49.94	38.67

SERIES XXII., SUDAN GRASS (FIRST CROP, SECOND CUTTING), PERIOD 6.

Sheep IX.

700 grams Sudan grass (second cutting, dry) fed.	616.49	59.61	95.49	205.41	246.53	9.43
Minus 266.71 grams feces excreted, . .	251.56	26.54	34.03	64.90	119.29	6.79
Sudan grass digested, ...	364.93	33.07	61.46	140.51	127.24	2.64
Per cent. digested, ...	59.19	55.48	64.36	68.40	51.57	28.00

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXII., SUDAN GRASS (FIRST CROP, FIRST CUTTING), PERIOD 7.

Sheep XI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
700 grams Sudan grass (first cutting, dry) fed,	615.44	61.97	88.93	204.33	250.73	9.48
Minus 5.57 grams of waste, ...	5.23	.69	.49	2.15	1.84	.05
Amount consumed, ...	610.21	61.28	88.44	202.18	248.89	9.43
Minus 283.26 grams feces excreted, . .	266.94	27.01	38.36	67.96	126.34	7.26
Sudan grass (first cutting) digested, . .	343.27	34.27	50.08	134.22	122.55	2.17
Per cent. digested, ...	56.25	55.92	56.63	66.38	49.24	23.01
Sheep XII.						
700 grams Sudan grass (first cutting, dry) fed,	615.44	61.97	88.93	204.33	250.73	9.48
Minus 94.43 grams of waste, ...	81.92	10.78	9.72	29.42	31.09	.91
Amount consumed, ...	533.52	51.19	79.21	174.91	219.64	8.57
Minus 253.21 grams feces excreted, . .	239.33	24.87	35.47	58.73	112.58	7.68
Sudan grass (first cutting) digested, . .	294.19	26.32	43.74	116.18	107.06	.89
Per cent. digested, ...	55.14	51.42	55.22	66.42	48.74	10.38
Sheep XIII.						
700 grams Sudan grass (first cutting, dry) fed,	615.44	61.97	88.93	204.33	250.73	9.48
Minus 278.76 grams feces excreted, . .	263.73	26.69	37.50	67.80	124.11	7.62
Sudan grass (first cutting) digested, . .	351.71	35.28	51.43	136.53	126.62	1.86
Per cent. digested, ...	57.15	56.93	57.83	66.82	50.51	19.62
Average per cent. digested, . . .	56.18	54.76	56.56	66.54	49.50	17.67
SERIES XXII., ENGLISH HAY, PERIOD 8. *Sheep IV.*						
800 grams English hay fed, ...	719.36	49.28	59.35	236.60	357.23	16.90
Minus 295.57 grams feces excreted, . .	279.11	29.20	29.50	77.65	133.42	9.35
English hay digested, ...	440.25	20.08	29.85	158.95	223.81	7.55
Per cent. digested, ...	61.20	40.75	50.30	67.18	62.65	44.67

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXII., ENGLISH HAY, PERIOD 8 — *Concluded.*

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	719.36	49.28	59.35	236.60	357.23	16.90
Minus 282.37 grams feces excreted,	266.70	28.51	28.86	72.62	127.51	9.20
English hay digested,	442.66	20.77	30.49	163.98	229.72	7.70
Per cent. digested,	61.54	42.15	51.37	69.31	64.31	45.56
Average per cent. digested,	61.37	41.45	50.84	68.25	63.48	45.12

SERIES XXII., VINEGAR GRAINS, PERIOD 9.

Sheep IX.

250 grams vinegar grains fed,	230.55	5.79	47.40	46.41	116.01	14.94
550 grams English hay fed,	495.72	35.59	41.49	167.55	239.18	11.90
Amount consumed,	726.27	41.38	88.89	213.96	355.19	26.84
Minus 309.94 grams feces excreted,	297.60	27.14	37.91	78.21	145.44	8.90
Amount digested,	428.67	14.24	50.98	135.75	209.75	17.94
Minus English hay digested,	302.39	14.59	21.16	113.93	150.68	5.36
Vinegar grains digested,	126.28	–	29.82	21.82	59.07	12.58
Per cent. digested,	54.77	–	62.91	47.02	50.92	84.20

Sheep XI.

Amount consumed as above,	726.27	41.38	88.89	213.96	355.19	26.84
Minus 318.83 grams feces excreted,	297.05	29.11	39.63	76.55	143.45	8.32
Amount digested,	429.22	12.27	49.26	137.41	211.74	18.52
Minus English hay digested,	302.39	14.59	21.16	113.93	150.68	5.36
Vinegar grains digested,	126.83	–	28.10	23.48	61.06	13.16
Per cent. digested,	55.01	–	59.28	50.59	52.63	88.08
Average per cent. digested,	54.89	–	61.10	48.80	51.77	86.14

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXII., VINEGAR GRAINS, PERIOD 10.

Sheep IV.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
250 grams vinegar grains fed,	231.33	5.95	46.77	46.54	116.45	15.61
550 grams English hay fed,	495.00	36.23	43.07	159.10	244.33	12.18
Amount consumed,	726.33	42.18	89.84	205.64	360.78	27.79
Minus 285.43 grams feces excreted,	272.59	25.60	35.38	69.10	143.14	8.37
Amount digested,	453.74	16.58	54.46	136.54	217.64	19.42
Minus English hay digested,	301.95	14.85	21.97	108.19	153.93	5.48
Vinegar grains digested,	151.79	1.73	32.49	28.35	63.71	13.94
Per cent. digested,	65.60	29.08	69.47	60.92	54.71	89.30

Sheep VI.

Amount consumed as above,	726.33	42.18	89.84	205.64	360.78	27.79
Minus 281.57 grams feces excreted,	268.28	28.97	37.00	63.07	130.46	8.77
Amount digested,	458.05	13.21	52.84	142.57	230.32	19.02
Minus English hay digested,	301.95	14.85	21.97	108.19	153.93	5.48
Vinegar grains digested,	156.10	–	30.87	34.38	76.39	13.54
Per cent. digested,	67.48	–	66.00	73.87	65.60	86.70
Average per cent. digested,	66.54	29.08[1]	67.74	67.40	59.66	88.00

SERIES XXII., STEVENS' "44" DAIRY RATION, PERIOD 11.

Sheep IV.

250 grams of Stevens' "44" Dairy Ration fed,	227.65	9.49	61.35	29.32	112.82	14.66
550 grams English hay fed,	499.13	33.69	41.08	164.56	247.47	12.33
Amount consumed,	726.78	43.18	102.43	193.88	360.29	26.99
Minus 269.57 grams feces excreted,	257.14	26.90	31.09	68.68	122.50	7.97
Amount digested,	469.64	16.28	71.34	125.20	237.79	19.02
Minus English hay digested,	304.47	13.81	20.95	111.90	155.90	5.55
Stevens' "44" Dairy Ration digested,	165.17	2.47	50.39	13.30	81.89	13.47
Per cent. digested,	72.55	26.03	82.14	45.36	72.58	91.88

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[1] One sheep only.

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXII., STEVENS' "44" DAIRY RATION, PERIOD 11 — *Concluded.*

Sheep VI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	726.78	43.18	102.43	193.88	360.29	26.99
Minus 277.79 grams feces excreted,	266.18	30.93	34.10	65.85	126.28	9.02
Amount digested,	460.60	12.25	68.33	128.03	234.01	15.97
Minus English hay digested,	304.47	13.81	20.95	111.90	155.90	5.55
Stevens' "44" Dairy Ration digested,	156.13	–	47.38	16.13	78.11	10.42
Per cent. digested,	68.58	–	77.23	55.01	69.23	71.08
Average per cent. digested,	70.57	26.03[1]	79.69	50.19	70.91	81.48

SERIES XXII., NEW YORK ALFALFA (THIRD CUTTING), PERIOD 2.

Sheep IV.

800 grams New York alfalfa (third cutting) fed.	700.96	42.27	105.92	248.28	291.11	13.39
Minus 306.21 grams feces excreted,	293.69	24.73	28.43	131.78	97.59	11.16
Alfalfa digested,	407.27	17.54	77.49	116.50	193.52	2.23
Per cent. digested,	58.10	41.50	73.16	46.92	66.48	16.66

Sheep VI.

800 grams New York alfalfa (third cutting) fed.	700.96	42.27	105.92	248.28	291.11	13.39
Minus 4.57 grams waste,	4.14	.17	.27	2.19	1.47	.03
Amount consumed,	696.82	42.10	105.65	246.09	289.64	13.36
Minus 330.53 grams feces excreted,	315.33	30.27	33.61	134.99	105.13	11.32
Alfalfa digested,	381.49	11.83	20.04	111.10	184.51	2.04
Per cent. digested,	54.75	28.10	68.19	45.15	63.70	15.27
Average per cent. digested,	56.43	34.80	70.68	46.04	65.09	15.97

SERIES XXII., ENGLISH HAY, PERIOD 13.

Sheep XII.

700 grams English hay fed,	636.09	45.73	51.78	211.56	311.81	15.20
Minus 268.70 grams feces excreted,	256.15	23.54	24.23	78.46	121.20	8.68
English hay digested,	379.94	22.19	27.55	133.10	190.61	6.52
Per cent. digested,	59.73	48.52	53.20	62.91	61.13	41.89

[1] One sheep only.

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXII., ENGLISH HAY, PERIOD 13 — *Concluded.*

Sheep XIII.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
700 (minus 1.67 grams waste) equals 698.33 grams English hay fed.	634.57	45.63	51.65	211.06	311.07	15.17
Minus 281.36 grams feces excreted,	266.79	25.43	26.68	80.12	125.87	8.70
English hay digested,	367.78	20.20	24.97	130.94	185.20	6.47
Per cent. digested,	57.96	44.27	48.37	72.04	57.54	42.65
Average per cent. digested,	58.85	46.40	50.77	62.48	60.34	42.77

SERIES XXII., NEW YORK ALFALFA (THIRD CUTTING), PERIOD 14.

Sheep XII.

700 grams New York alfalfa (third cutting) fed.	638.75	44.37	99.45	221.65	260.10	13.16
Minus 269.07 grams feces excreted,	257.96	22.13	27.42	114.64	84.59	9.18
Alfalfa digested,	380.79	22.26	72.03	107.01	175.51	3.98
Per cent. digested,	59.61	50.15	72.43	48.28	67.48	30.24

Sheep XIII.

700 grams New York alfalfa (third cutting) fed.	638.75	44.37	99.45	221.65	260.10	13.16
Minus 277.50 grams feces excreted,	265.04	21.89	26.53	121.39	86.32	8.91
Alfalfa digested,	373.71	22.50	72.92	100.26	173.78	4.25
Per cent. digested,	58.50	50.68	73.32	45.23	66.81	32.29
Average per cent. digested,	59.06	50.42	72.88	46.76	67.15	31.26

SERIES XXII., ROWEN, PERIOD 15.

Sheep XII.

700 grams rowen fed,	636.09	51.65	82.88	179.06	300.80	21.69
Minus 259.10 grams feces excreted,	249.25	33.97	32.83	57.08	110.19	15.18
Rowen digested,	386.84	17.68	50.05	121.98	190.61	6.51
Per cent. digested,	60.81	34.23	60.39	68.12	63.37	30.01

Sheep XIII.

700 grams rowen fed,	636.09	51.65	82.88	179.06	300.80	21.69
Minus 257.74 grams feces excreted,	247.04	33.18	32.93	57.17	109.56	14.20
Rowen digested,	389.05	18.47	49.95	121.89	191.24	7.49
Per cent. digested,	61.16	35.76	60.27	68.08	63.57	34.53
Average per cent. digested,	60.99	35.00	60.33	68.10	63.47	32.27

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Continued.*

SERIES XXII., SWEET CLOVER (GREEN), PERIOD 16.

Sheep IX.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
400 grams English hay fed,	359.48	25.92	32.57	109.03	182.04	9.92
1,600 grams sweet clover fed,	232.00	10.67	49.79	62.13	101.52	7.89
Amount consumed,	591.48	36.59	82.36	171.16	283.56	17.81
Minus 246.07 grams feces excreted,	228.30	27.36	28.67	72.71	107.38	9.94
Amount digested,	363.18	9.23	53.69	98.45	176.18	7.87
Minus hay digested,	208.50	11.66	15.63	68.89	109.22	4.46
Sweet clover digested,	154.68	–	38.06	29.56	66.96	3.41
Per cent. sweet clover digested,	66.67	–	76.44	47.60	65.96	43.22

Sheep XI.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	591.48	36.59	82.36	171.16	283.56	17.81
Minus 231.36 grams feces excreted,	214.52	24.89	25.91	69.78	102.26	8.51
Amount digested,	376.96	11.70	56.45	101.38	181.30	9.30
Minus hay digested,	208.50	11.66	15.63	68.89	109.22	4.46
Sweet clover digested,	168.46	.04	40.82	32.49	72.08	4.84
Per cent. sweet clover digested,	72.61	.03	81.98	52.29	71.00	61.34
Average per cent. sweet clover digested,	69.64	.03	79.21	49.95	68.48	52.28

SERIES XXII., SUDAN GRASS (GREEN), PERIOD 17.

Sheep XII.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
400 grams English hay fed,	352.28	24.69	30.79	117.63	169.27	9.90
1,600 grams Sudan grass (green, first cutting) fed.	313.28	22.49	44.58	95.02	136.43	14.75
Amount consumed,	665.56	47.18	75.37	212.65	305.70	24.65
Minus 235.01 grams feces excreted,	215.74	16.27	24.18	58.53	109.14	7.62
Amount digested,	449.82	30.91	51.19	154.12	196.56	17.03
Minus hay digested,	207.85	11.36	15.70	72.93	101.56	4.26
Sudan grass (green, first cutting) digested,	241.97	19.55	35.49	81.19	95.00	12.77
Per cent. Sudan grass (green, first cutting) digested.	77.23	86.93	79.61	85.45	69.63	86.57

TABLE V. — COMPUTATION OF DIGESTION COEFFICIENTS — *Concluded.*

SERIES XXII., SUDAN GRASS (GREEN), PERIOD 17 — *Concluded.*

Sheep XIII.

ITEM.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	665.56	47.18	75.37	212.65	305.70	24.65
Minus 253.04 grams feces excreted,	235.78	26.83	24.38	65.90	110.13	8.54
Amount digested,	429.78	20.35	50.99	146.75	195.57	16.11
Minus hay digested,	207.85	11.36	15.70	72.93	101.56	4.26
Sudan grass (green, first cutting) digested,	221.93	8.99	35.29	73.82	94.01	11.85
Per cent. Sudan grass (green, first cutting) digested.	70.84	39.96	79.16	77.69	68.97	80.34
Average per cent. Sudan grass (green, first cutting) digested.	74.04	63.45	79.38	81.57	69.30	83.46

DISCUSSION OF THE RESULTS.

Having presented in the foregoing pages a statement of the general purpose of these experiments, an explanation of the tables, and the data of the composition of the feeds and feces, as well as the detailed data of the experiments, including the computation of the digestion coefficients, it is intended in the pages which follow to state briefly the general character of each feed, summarize the coefficients secured, and draw such conclusions as the results indicate.

In noting the variations which occur when the same feed is fed to different sheep, the fact must not be lost sight of that digestibility is made up of a number of processes. Armsby states the matter clearly when he says "digestibility in ruminants is a very complex affair, depending on many factors; . . . it may be characterized as a series of fermentations effected in part by a variety of organized ferments, and in part by enzymes secreted by the digestive organs or contained in the feed itself. Changes in the composition of the contents of the digestive tract, or in the rapidity with which they move forward through it, can hardly fail to influence in a variety of ways the course of these fermentations, and it seems, on the whole, rather surprising that they go forward as rapidly as they do."

Summary of Coefficients of English Hay — Basal.

Lot.	Series.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
1	XIX.	3	I.	59.77	20.59	49.08	64.84	64.07	38.42
1	XIX.	3	II.	57.65	23.90	53.12	58.93	62.39	38.17
1	XIX.	9	V.	60.57	33.50	53.53	63.32	63.29	57.47
1	XIX.	9	VI.	57.53	32.81	51.10	58.66	60.84	54.99
Average, ...				58.88	27.70	51.71	61.45	62.72	47.26
2	XX.	1	I.	64.70	39.69	50.86	70.41	66.78	84.67
2	XX.	1	II.	63.43	36.98	50.38	68.33	66.06	47.96
2	XX.	6	IV.	60.08	42.04	48.34	63.10	62.51	39.26
2	XX.	10	VII.	56.80	42.70	52.25	59.57	58.27	43.15
2	XX.	10	VIII.	59.70	44.21	52.72	62.44	61.96	41.83
Average, ...				60.94	41.12	50.91	64.77	63.12	51.39
3	XXI.	2	VII.	54.89	28.25	42.00	58.88	58.62	42.44
3	XXI.	2	VIII.	61.70	37.65	45.08	68.06	64.39	44.65
3	XXI.	9	IX.	58.21	40.25	42.18	62.65	60.86	46.52
3	XXI.	9	X.	56.37	43.47	46.81	59.36	58.50	40.87
3	XXI.	9	XI.	53.82	38.14	40.07	56.46	57.13	39.27
Average, ...				57.00	37.55	43.23	61.08	59.90	42.71
4	XXI.	13	XII.	60.69	39.10	54.81	65.30	64.70	53.07
4	XXI.	13	XIII.	60.15	35.89	54.01	62.63	64.49	48.78
4	XXI.	13	XIV.	57.64	35.31	50.89	61.07	62.59	50.23
4	XXII.	2	IV.	61.21	29.31	53.63	67.57	64.37	40.96
4	XXII.	2	VI.	62.52	26.61	47.96	70.21	66.75	40.62
Average, ...				60.44	31.24	52.26	65.36	64.58	46.73
5	XXII.	8	IV.	61.20	40.75	50.30	67.18	62.65	44.67
5	XXII.	8	VI.	61.54	42.15	51.37	69.31	64.31	45.56
5	XXII.	13	XII.	59.73	48.52	53.20	62.91	61.13	41.89
5	XXII.	13	XIII.	57.96	44.27	48.37	72.04	57.54	42.65
Average, ...				60.11	43.92	50.81	67.86	61.41	43.69
Grand average, ...				59.47	36.31	49.78	64.10	62.35	46.34

Five distinct lots of hay were used in these experiments. The hay was cut when in bloom from an old mowing, and was composed largely of Kentucky blue grass (*Poa pratensis*) and sweet vernal grass (*Anthoxanthum odoratum*) with an admixture of more or less clover. The results, on the whole, are reasonably uniform, although one notes occasional variations, particularly in the fiber and also in the protein, due evidently to the individuality and perhaps to particular condition of the sheep.

The last two lots were evidently of somewhat better quality, or perhaps cut a little earlier than the first two, for they showed a somewhat superior digestibility. All five lots were more fully digested than is timothy hay. Note that the fiber in the hay has a digestibility slightly above the extract matter. This is characteristic of many coarse feeds.

Summary of Coefficients of English Hay and Gluten Feed — Basal.

Lot.		Series.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Hay.	Gluten Feed.									
1	1	XIX.	2	V.	66.13	34.59	67.91	64.67	69.82	56.13
1	1	XIX.	2	VI.	66.61	27.03	68.79	66.60	70.21	56.53
1	2	XIX.	15	V.	66.70	42.45	64.22	66.36	70.29	54.23
1	2	XIX.	15	VI.	66.22	39.97	59.69	60.35	66.48	48.23
2	2	XX.	5	I.	70.34	41.09	66.45	74.12	72.80	60.56
2	2	XX.	5	II.	66.69	28.84	61.42	69.60	70.70	58.33
2	2	XX.	14	IV.	60.31	27.12	63.45	60.34	63.53	50.95
2	2	XX.	14	V.	63.23	29.01	64.01	65.99	66.05	46.73
2	2	XX.	14	VI.	63.74	31.94	64.71	65.92	66.31	51.93
3	3	XXI.	1	IV.	64.97	31.78	68.38	65.52	68.73	46.03
3	3	XXI.	1	V.	66.92	23.83	68.53	68.50	71.74	47.76
3	3	XXI.	1	VI.	68.81	32.51	70.34	71.07	72.53	49.21
4	3	XXI.	11	V.	70.49	40.50	70.34	73.81	74.35	48.94
4	3	XXI.	11	VI.	71.17	34.90	71.19	75.67	75.24	50.94
Average,					66.59	33.25	66.39	67.75	69.91	51.89

In many cases it was thought wise to use a basal ration composed of English hay and gluten feed in order to secure a combination better balanced as regards protein and carbohydrates than is hay. Gluten feed was selected to be used with the hay because it contained a moderate amount of protein and is usually quite fully digested. In Series XIX. a combination of 650 grams of hay and 125 grams of gluten feed was used, and in the other cases 550 grams of hay and 150 grams of gluten feed.

The results of Period 14, Series XX., are rather surprising, and in a way hardly to be explained, being noticeably below Series XXI., Periods 1 and 11, which are reasonably uniform. They will be discussed further in considering the digestibility of gluten feed. Series XIX., Period 15, has more hay in proportion to gluten feed, and the coefficients are somewhat below the other series, with the exceptions mentioned.

Summary of Coefficients of English Hay, Potato Starch and Diamond Gluten Meal — Basal.

Lot.		Series.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Hay.	Starch and Gluten.									
1	1	XIX.	10	III.	73.45	33.70	73.48	59.62	80.71	34.29
1	1	XIX.	10	IV.	70.47	13.22	71.02	55.41	78.91	32.67
1	1	XIX.	11	IV.	72.17	33.93	75.02	60.73	78.39	47.07
2	1	XXI.	5	IV.	72.77	19.38	71.12	64.26	80.63	32.29
2	1	XXI.	5	V.	77.28	9.41	75.33	74.73	84.15	41.00
2	1	XXI.	5	VI.	73.49	13.30	71.93	66.46	81.24	35.66
Average,					73.27	20.16	72.98	63.54	80.67	37.16

In order to study the digestibility of fiber in distillers' grains and corn bran, a basal ration composed of a limited amount of hay plus potato starch and Diamond gluten meal was used. This ration naturally contained but little fiber, and would permit the intestinal juices and ferments to exert their maximum effect upon the fiber of the two by-products.

Sheep IV. in Series XIX. received 100 grams more hay and 25 grams more gluten meal daily in the combination than did the other three sheep. The coefficients of this basal ration are fairly uniform, excepting that Sheep V. appeared to have digested noticeably more of the ration than did the other sheep.

Summary of Coefficients of Gluten Feed (Present Experiments).

Series.	Period.	Sheep.	Brand.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XIX.	2	V.	–	91.80	167.00	87.50	99.00	94.70	72.50
XIX.	2	VI.	–	94.70	–	89.50	126.00	96.30	73.60
XIX.	14	V.	–	112.09	337.98	84.78	208.85	110.89	59.91
XIX.	14	VI.	–	94.54	258.91	89.69	116.36	94.63	53.50
XIX.	15	V.	Clinton	106.57	163.22	82.62	173.28	108.91	50.00
XIX.	15	VI.	Clinton	78.90	129.89	71.28	47.41	87.34	29.55
XX.	5	I.	Clinton	93.42	75.66	84.70	145.65	94.25	87.60
XX.	5	II.	Clinton	76.50	–	73.73	77.96	85.50	80.45
XX.	14	IV.	Clinton	50.38	–	76.15	–	58.65	63.55
XX.	14	V.	Clinton	64.07	–	77.25	51.82	69.51	50.32
XX.	14	VI.	Clinton	66.47	–	78.61	50.80	70.63	66.01
XXI.	1	IV.	Buffalo	93.87	–	92.96	136.00	95.88	63.27
XXI.	1	V.	Buffalo	102.79	–	93.16	185.00	108.12	74.69
XXI.	1	VI.	Buffalo	111.63	–	96.82	228.00	111.46	84.49
XXI.	11	V.	Buffalo	112.30	73.00	93.20	231.00	105.00	38.00
XXI.	11	VI.	Buffalo	115.40	15.00	95.10	259.00	108.50	51.00
Average, ...				91.59	–	85.44	142.41	93.77	64.41

The gluten feed represented in these trials comprised three different lots of the same general type of chemical composition. It contained approximately 9 per cent. of water; and in dry matter the ash varied from .95 to 3.49 per cent., the protein from 25.47 to 28.29 per cent., the fiber from 7.30 to 8.70 per cent., the extract matter from 56.86 to 59.70 per cent., and the fat from 1.56 to 4.94 per cent. In general appearance the three samples resembled each other closely. The variations in percentage of ash and fat indicated some little difference in the manufacturing process, but not sufficient to warrant any noticeable variations in the digestibility of the several lots. In fact, the gluten feed used in Series XIX., Periods 2 and 14, and the same series, Period 15, were two different lots, and yet they resemble each other closely in digestibility.

Here follow the results of a number of early experiments. The process of manufacture was somewhat different, more of the germ being retained resulting in a higher fat percentage. The ash also was not much over 1 per cent. because the evaporated steep water was not added. Rather wide variations are noted as in the later experiments.

Summary of Earlier Work with Gluten Feed.

Digestion Coefficients.

Year.	Series.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
1893	-	2	II.	75.53	-	85.97	39.92	78.44	82.25
1893	-	2	IV.	80.44	-	83.94	46.28	84.37	80.58
1894	-	5	III.	89.35	-	88.69	94.69	88.93	92.74
1894	-	5	IV.	91.11	-	88.88	104.56	89.76	95.61
1896	-	-	-	87.00	-	86.00	77.00	90.00	81.00
1906	-	8	IV.	93.78	78.07	89.26	123.46	93.42	75.70
1906	-	8	V.	97.83	98.67	92.91	128.92	97.03	79.68
1909	XI.	7	IV.	92.25	85.05	90.02	107.23	92.30	76.29
1909	XI.	7	V.	99.24	93.69	92.22	153.69	97.98	77.29
1909	XII.	4	IV.	94.58	-	91.22	127.83	96.09	77.09
1909	XII.	4	V.	95.18	-	89.65	146.29	97.60	57.82
1909	XII.	14	II.	75.30	-	68.83	63.62	83.32	67.06
1909	XIV.	3	I.	99.18	77.54	87.31	134.91	103.30	97.79
1909	XIV.	3	II.	90.98	34.40	83.32	119.00	99.04	81.26
1909	XIV.	5	III.	85.81	51.15	81.84	81.74	94.04	79.46
1909	XIV.	5	IV.	101.55	64.83	88.58	147.10	108.24	84.21

Average Results.

Present experiments, ...	91.59	-	85.44	142.41	93.77	64.41
Earlier experiments, ...	90.57	-	86.79	106.01	93.36	80.36

Averages are not particularly satisfactory, especially when the figures from which they are made up vary widely among themselves. The foregoing averages show, however, the gluten feed to have a high digestibility.

A study of the numerous results brings out at least two striking facts. In the first place, in some experiments the coefficients are very much higher than in others. Thus, Series XX., Period 14, gave results very noticeably below the others.

It is the belief of the writer, however, that at least a part of the variation is due to the lessened activity of the digestive processes, even though such a condition may not be indicated by any outward signs. The changing from one ration to another may also change the intestinal flora.

In the second place, it is observed that in a number of instances the gluten feed appears to be over 100 per cent. digestible. It seems reasonable to assume that this is due to its favorable effect in increasing the digestibility of the hay; this condition was particularly pronounced in case of the fiber and to a lesser extent in the extract matter, and is in accord with the accepted teaching of the favorable influence of a protein concentrate on the fiber and extract matter of a basal ration having a wide nutritive ratio.

The digestibility of the protein varied in proportion to the digestibility of the extract matter, and is shown to be quite well utilized. The fat showed wide variations, due in part to the small amount present, and in part to other causes. The ash content of gluten feed is not large, and in most cases more ash was excreted from the total ration than was contained in the gluten feed fed, so that coefficients for this ingredient cannot be deduced.

Average Coefficients for All Results.

Different lots,	7
Number of single trials,	32
Dry matter,	91.08
Ash,	–
Protein,	86.12
Fiber,	124.21
Nitrogen-free extract,	93.57
Fat,	72.39

The average results for all samples indicate very clearly that gluten feed is a highly digestible nitrogenous concentrate, and that in all probability it exerts a favorable influence upon the digestibility of a basal ration having a wide nutritive ratio.

Summary of Coefficients for Diamond Gluten Meal.

SERIES.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XIX.,	10	IV.	83	143	83.8	–	90.5	–
XIX.,	10	III.[1]	68	–	80.0	–	79.0	–
XIX.,	11	IV.	87	127	86.4	–	91.4	47.3
XXI.,	5	IV.	86	–	84.8	100	93.3	–
XXI.,	5	V.[1]	109	–	91.2	100	120.1	–
XXI.,	5	VI.	90	–	86.0	100	97.2	–
Average,[1]			86	–	85.0	100	93.0	–
Average of previous results (8),			87	–	88.0	–	88.0	93.0

[1] Results from Sheep III. and V. omitted from average.

A combination of 300 to 400 grams of hay, 125 grams of potato starch, and 100 to 125 grams of Diamond gluten meal were fed as a basal ration in order to study the digestibility of distillers' dried grains and corn bran. It seemed worth while in this connection to get at the digestibility of the Diamond gluten meal. In order to accomplish this the digestion coefficients found for the hay were applied to the hay consumed, and to the resulting product was added the amount of starch consumed, which was assumed to be entirely digested. The sum of the hay and starch digested was taken from the total amount digested, and the remainder represented the gluten meal digested. The coefficients used for the hay in case of Series XIX. represented an average of those secured by using the results from Sheep I., II., V. and VI., all of which agreed closely. Those used in Series XXI. were the average of those for Sheep VII., VIII., IX., X. and XI., as IV., V. and VI. had not been used in getting the digestibility of this lot of hay. The coefficients for the hay were as follows: —

Series.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XIX., ...	59	28	52	62	62	47
XXI., ...	57	37	43	61	60	45

The nutritive ratio of the basal ration in Series XIX. averaged 1:6.5 and in Series XXI., 1:6.8.

In passing, attention is called to the fact that the ash, fiber and fat content of gluten meal are quite low, showing less than 2 per cent. of each on a dry-matter basis, and the coefficients secured were, as might be expected, of uncertain value, although it is reasonable to assume that these several constituents were quite fully digested.

The content of protein and extract matter, on the other hand, on the basis of dry matter, was 45 and 50 per cent., respectively, showing this feedstuff to be made of these two food groups in nearly equal proportions.

A study of the coefficients secured shows some wide variations. Sheep III., Series XIX., for some reason gave quite low results, and in Series XXI., Sheep V gave results considerably above the others. In making the average, therefore, it seemed wise to omit the coefficients obtained with these two sheep. The results show the gluten meal to have a high digestibility; in fact, it is believed that if a method sufficiently accurate were available it could be shown that the meal was practically all utilized.

The coefficients given for previous results represent eight single trials with four different lots, and were secured a number of years ago with gluten meal made by a little different process and averaging 40 per cent. protein and 54 per cent. extract matter in dry matter. The latter coefficients are in substantial accord with those recently secured.

Summary of Coefficients showing Effect of High-grade Wheat Gluten Flour upon Digestibility of Hay.

Series.	Period.	Sheep.	Dry Matter.		Ash.		Protein.		Fiber.		Extract Matter.		Fat.	
			With.	Without.	With.	Without.	With.	Without.	With.	Without.	With.	Without.	With.	Without.
XX.	10 and 12,	VII.	59	57	48	43	43	52	62	60	61	58	46	43
XX.	10 and 12,	VIII.	60	60	46	44	40	53	64	62	62	62	48	42
Average, . . .			59	58	47	43	41	52	63	61	62	60	47	42

The object of this trial was to observe the effect of a high-grade wheat gluten flour, composed largely of protein, upon the digestibility of the hay. In the hay experiment 600 grams were fed to each of two sheep, and in the experiment immediately following 40 grams of the gluten were added to the hay.

The hay contained in dry matter 6.66 per cent. ash, 8.36 protein, 32.08 fiber, 50.40 extract matter and 2.50 fat, and had a nutritive ratio of 1:12. The wheat gluten contained in dry matter .86 per cent. ash, 92.41 protein, .11 fiber, 6.23 extract matter and .39 fat, being nearly pure gluten meal, with traces of ash, fiber and fat, and a small amount of extract matter. The nutritive ratio of the hay-gluten mixture was 1:6. A study of the comparative coefficients of the hay when fed with and without the gluten — assuming the gluten to have been entirely digested — indicates that the latter improved the digestibility of the hay slightly, particularly the fiber, extract matter and fat. The protein, on the other hand, showed an apparent lessened digestibility, due perhaps to the fact that the protein of the gluten was not completely assimilated.

Applying the coefficients secured for the hay when fed by itself to the same hay fed in combination with wheat gluten, and subtracting the result from the total amount of hay plus gluten digested, we find that in case of one sheep 47.48 grams, and in case of the other, 33.95 grams, were digested against 36.36 grams fed. This indicates that in one case at least the gluten was not only fully digested but improved somewhat the digestibility of the hay.

Summary of Coefficients showing Effect of High-grade Wheat Gluten Flour upon Digestibility of Hay — Continued.

			Dry Matter.		Ash.		Protein.		Fiber.		Extract Matter.		Fat.	
Series.	Period.	Sheep.	With.	Without.	With.	Without.	With.	Without.	With.	Without.	With.	Without.	With.	Without.
XXI.	4[1]	VII.	55	55	36	28	45	42	58	59	58	59	44	42

[1] In case of hay alone, period 2.

This experiment was with a new lot of hay, testing in dry matter 6.59 per cent. ash, 7.59 per cent. protein, 32.67 per cent. fiber, 50.29 per cent. extract matter and 2.86 per cent. fat, and having a nutritive ratio of about 1:17, being very wide. The wheat gluten was the same as the lot previously fed, and the combination of 700 grams hay and 40 grams wheat gluten had a nutritive ratio of 1:5.7. In other words, the addition of 40 grams of gluten to 700 grams of hay produced a much narrower ration than if the hay had been fed by itself. A study of the coefficients shows no particular improvement in the digestibility of the hay as a result of adding the gluten, although such an improvement was anticipated.

Applying the coefficients secured for the hay when fed by itself to the same hay fed in combination with wheat gluten, and subtracting the result from the total amount of hay plus gluten digested, we have 38.58 grams of gluten digested as against 37.18 grams fed, showing the gluten to have been completely digested.

Summary of Coefficients showing Effect of High-grade Wheat Gluten Flour upon Digestibility of Hay — Concluded.

			Dry Matter.		Ash.		Protein.		Fiber.		Extract Matter.		Fat.	
Series.	Period.	Sheep.	With.	Without.	With.	Without.	With.	Without.	With.	Without.	With.	Without.	With.	Without.
XXI.	10[1]	IV.	61	57	46	37	47	43	66	61	64	60	38	45
XXI.	10[1]	VI.	61	57	44	37	46	43	67	61	63	60	39	45
Average, . . .			61	57	45	37	46	43	66	61	63	60	38	45
Average of all trials (5),			58	57	43	36	44	46	62	61	61	60	43	43

[1] In case of hay alone, periods 2 and 9.

The hay was the same as fed in the former trial; the gluten was a new lot, but did not vary in composition much from the previous sample used. Unfortunately, Sheep IV. and VI. were not used in testing the digestibility of the hay, and the coefficients represent the average obtained by using Sheep VII., VIII., IX., X. and XI. It is evident in this trial that the gluten did improve the digestibility of the hay somewhat, particularly the fiber and extract matter.

Experiments by numerous investigators[1] have shown that when a ration containing considerable starch, and having a nutritive ratio of 1:12 or more, is fed to ruminants more or less of the starch is found in the feces, and if to this ration a protein concentrate is added the starch disappears, and the digestion coefficients, not only of the extract matter but also of the fiber, are improved. In our own case the addition of a small amount of a very rich protein food to hay improved the digestibility of the latter, but not in as marked a way as was expected.

Summary of Coefficients of Corn Bran.

SERIES.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XIX., ...	13	I.	90.08	210.29	49.64	99.91	90.24	74.88
XIX., ...	13	II.	77.09	129.04	26.03	66.90	82.70	45.52
XXI., ...	7	IV.	78.23	–	58.78	67.49	82.27	63.57
XXI., ...	7	V.	81.89	–	22.56	96.10	86.33	65.16
XXI., ...	7	VI.	75.66	–	61.83	49.20	84.21	78.51
Average, ...			80.59	–	43.77	75.92	85.15	65.53
Average of previous trials (2), .			71	–	55	65	75	83
Average of all previous trials (6),			71	–	60	71	80	80

The corn bran represents the hull or skin of the kernel, together with pieces of broken germ and more or less of the starchy portion which it is not possible to separate by mechanical means. It is often found in the markets of Massachusetts, and has been offered at a very reasonable price. In dry matter it contained 1.08 per cent. ash, 6.87 per cent. protein, 13.86 per cent. fiber, 76.33 per cent. extract matter and 1.86 per cent. fat. While low in ash and protein, its fiber content is not excessive, and it is quite rich in extract matter.

The hay-gluten meal-starch combination served as the basal ration. For some reason Sheep I., as indicated by the digestion coefficients, appeared to have utilized the bran quite fully. The results secured with the other sheep were as uniform as was to be expected, although Sheep II. and V. apparently made less use of the protein, while the latter sheep gave a high coefficient for the fiber.

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[1] See brief résumé in Die Ernährung d. landw. Nützthiere, by Kellner, sixth ed., pp. 53, 54.

The results are higher than those formerly secured by us, where the corn bran was fed together with hay, excepting those for protein and fat. It is evident that the fiber is quite well digested, much more so than that contained in wheat and oats. Comparing the corn bran with corn meal on the basis of net energy values it is found that if corn meal is placed at 100 corn bran equals 82.

Summary of Coefficients of Distillers' Grains.

SERIES.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XIX., . . .	12	IV.	65.79	–	79.47	16.21	70.55	93.22
XXI., . . .	6	IV.	64.88	64.51	77.26	43.89	63.17	81.99
XXI., . . .	6	V.	67.54	21.21	74.23	62.67	66.63	82.48
XXI., . . .	6	VI.	67.94	23.21	77.24	54.98	69.16	77.10
Average, ...			66.54	36.31	77.05	44.44	67.38	83.70
Average of all previous trials for corn grains (17).			79	–	73	95	81	95
Average of all previous trials for rye grains (2).			58	–	59	–	67	84

The object of this experiment was to study particularly the digestibility of the fiber. For this purpose the grains were added to the hay-Diamond-gluten-meal-starch basal ration, which was quite low in that ingredient.

Distillers' grains represent the residues from the manufacture of distilled spirits. Those containing a high protein percentage are derived largely from corn. On the basis of 10 per cent. water the two samples contained 26.51 and 23.76 per cent. of protein, and may be considered of fair quality. The best grades usually contain 30 or more per cent. of protein. On the dry matter basis the average of the two samples contained 2.07 per cent. ash, 27.92 per cent. protein, 13.67 per cent. fiber, 46.69 per cent. extract matter and 9.65 per cent. fat.

In the present experiments variations are observed in the percentages of the several ingredients digested. It is rather surprising that such differences occur in the percentages of fiber digested. It is evident, in spite of the low fiber content of the basal ration, that the sheep did not utilize the fiber from the distillers' grains very well, which indicates that other grains than corn were used in the mash. Previous trials with corn grains showed higher coefficients for the total dry matter and for the extract matter and fat (see above), while the coefficients for the fiber were believed to have been too high. It seems probable that in the former trials, where the distillers' grains were fed with hay, the addition of the former increased the digestibility of the hay fiber. It is believed that the extent of the digestibility of distillers' grains will depend upon the kind of grains composing the mash. If much rye, barley and wheat are used the coefficients, especially those for fiber, will be lower than when corn is the predominating grain.

Summary of Coefficients of Feterita.

Series.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XXI., . . .	12	V.	74.36	–	54.79	–	87.58	60.70
XXI., . . .	12	VI.	74.65	–	46.55	–	87.94	56.69
Average, ...			74.51	–	50.67	–	87.58	60.70
Texas Station,[1]			88.99	–	90.03	50.00	96.60	74.52
Corn for comparison (12), . . .			90	–	74	57	94	93

Feterita, or Sudan durra, is one of the grain sorghums, which include also Kafir, milo, durra and kaoliang. According to Morrison "it has slender stems carrying more leaves than milo but less than kafir, and erect heads bearing flattened seeds. Over much of the drier western portion of the grain sorghum belt these crops are more sure, and even on good soil return larger yields than corn." It has been stated that the average crop is 25 bushels per acre, with a maximum of 80 bushels (56 pounds) for feterita. The sample tested by us came from a carload received by an eastern grain dealer, and contained 10.41 per cent. water. Its dry matter consisted of 1.80 per cent. ash, 13.23 per cent. protein, 1.40 per cent. fiber, 80.23 per cent. extract matter and 3.34 per cent. fat. In chemical composition it resembles corn, being a little higher in protein and lower in fat. Hay and gluten feed served as a basal ration, and the feterita constituted 30 per cent. of the total ration. The results of the trial agree closely. It is surprising, however, that in total dry matter the coefficients fall so much below corn. Neither the protein nor the fat appear to be as well digested; the extract matter, however, approaches in digestibility that contained in corn. Corn contains substantially 85.7 pounds of digestible organic nutrients in 100, and on the basis of our results feterita contains 71.06 pounds, thus indicating that the latter has only 83 per cent. of the nutritive value of corn. There are no data from which to compute its net energy value. It is doubtful, however, if such data would show any wide variations from that secured as a result of digestion data. Further experiments with the feterita should be made, however, before drawing positive conclusions.[2]

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[1] See note 2.

[2] Since the above was written, Fraps of the Texas Station, Bul. No. 203, reports results with this grain showing higher digestion coefficients than those secured by ourselves. These coefficients are inserted above, together with our own.

Summary of Coefficients of Alfalfa.

SERIES.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XXII., ...	12	IV.	58.10	41.50	73.16	46.92	66.48	16.66
XXII., ...	12	VI.	54.75	28.10	68.19	45.15	63.70	15.27
XXII., ...	14	XII.	59.61	50.15	72.43	48.28	67.48	30.24
XXII., ...	14	XIII.	58.50	50.68	73.32	45.23	66.81	32.29
Average, ...			57.74	42.61	71.78	46.40	66.12	23.62
Average all previous trials third cutting (6).			58	44	70	40	70	42
Average all previous trials (109), .			60	50	71	43	72	38

The alfalfa was quite free from foreign material. It represented the third cutting, and was grown in the State of New York. It averaged in dry matter 6.49 per cent. ash, 15.34 per cent. crude protein, 35.06 per cent. fiber, 41.13 per cent. extract matter and 1.98 per cent. crude fat. The results are satisfactory and are quite uniform with those previously secured. The fiber in alfalfa hay has relatively a low, and the protein a high, digestibility.

Roots and Vegetables.

It is generally assumed that roots and vegetables are quite fully digested by animals. Relatively few digestion trials have been made to determine the rate of digestibility and to note the effect, if any, of such materials upon the digestibility of feeds with which they are fed.

(*a*) *Cabbages.*

The whole cabbage, the head minus the outside leaves, and the leaves themselves were analyzed and digestion experiments carried out. The whole cabbage contained 88.27 per cent. water, and its dry matter consisted of 12.20 per cent. ash, 21.82 per cent. protein, 10.30 per cent. fiber, 53.76 per cent. extract matter and 1.92 per cent. fat.

The heads minus leaves contained 90.34 per cent. water, and the dry matter consisted of 8.22 per cent. ash, 17.98 per cent. protein, 9.84 per cent. fiber, 62.77 per cent. extract matter and 1.19 per cent. fat.

The outside leaves contained 80.95 per cent. water, and the dry matter consisted of 14.49 per cent. ash, 11.94 per cent. protein, 13.12 per cent. fiber, 58.04 per cent. extract matter and 2.41 per cent. fat. The exterior leaves contained about twice as much dry matter as the heads.

Cabbage is rich in protein, — in fact, considerably richer than the legumes, — on an equal moisture basis. It is rich also in ash, particularly the leaves, which may have been due in part to the adherence of soil particles. The percentages of fiber and fat are relatively low.

The cabbage was fed in combination with hay, and constituted 25 to 34 per cent. of the dry matter of the total rations, the latter having nutritive ratios of from 1:6.6 to 1:9.

Summary of Coefficients for Cabbage.

Whole Cabbage.

SERIES.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XIX., . . .	7	I.	89.35	59.74	84.59	109.57	95.50	71.11
XIX., . . .	7	II.	86.49	54.19	87.67	72.48	96.22	68.33
Average, ...			87.92	56.97	86.13	91.03	95.86	69.72
				Heads Minus Leaves.				
XVIII., . .	4	I.	99.84	80.55	84.92	124.79	103.16	53.26
XVIII., . .	4	II.	95.81	74.02	68.15	99.74	101.48	32.07
Average, ...			97.83	77.29	76.54	112.27	102.32	42.67
				Leaves.				
XVIII., . .	5	I.	76.84	45.71	66.69	80.66	87.38	45.37
XVIII., . .	5	II.	71.39	44.23	60.90	75.79	81.30	29.40
Average, ...			74.12	44.97	63.80	78.23	84.34	37.39

The whole cabbage was quite well digested, with an average dry matter percentage in case of the two sheep of 88 per cent. The fiber averaged 91 per cent. digestible, showing in case at least of one of the sheep that it had improved the digestibility of the fiber in the hay. The extract matter also had a high digestibility (96 per cent.).

The heads proved rather more digestible than the whole cabbage, namely, 98 per cent., the protein 77 per cent., and both the fiber and extract matter over 100 per cent. It seems evident that the cabbage exercised a beneficial effect upon the hay with which it was fed.

The leaves did not prove as digestible as the center, although one notes that the dry matter averaged 74 per cent. digestible, the protein 64 per cent., the fiber 78 per cent. and the extract matter 84 per cent.

The whole cabbage, head minus leaves, and leaves would contain of digestible organic matter, on the basis of our data, in 2,000 pounds, the following: —

	Water (Per Cent.).	Protein (Pounds).	Fiber (Pounds).	Extract Matter (Pounds).	Fat (Pounds).	Total Fat x 2.2 (Pounds).	Nutritive Ratio.
Whole cabbage, . .	88.3	43.88	21.92	120.74	3.12	193.40	1:3.4
Head, . . .	90.3	26.73	19.32	123.20	1.17	171.82	1:5.4
Leaves, . . .	81.0	29.02	38.80	185.24	3.38	260.50	1:8.0

Because of the less moisture content the leaves show a larger amount of total organic nutrients than either the total cabbage or the interior. On the basis of 88.3 per cent. water, — that found in the whole cabbage, — the interior shows 207.2 and the leaves 160.4 pounds of digestible organic nutrients per ton. The whole cabbage, head and leaves, have the following relative values based upon digestible organic nutrients and natural moisture, or an equivalent moisture content of 88.3 per cent.: —

	Natural Moisture Basis.	Equal Moisture Basis.
Whole cabbage, ...	100	100
Head, ...	89	106
Leaves, ...	135	83

(b) Carrots.

Summary of Coefficients of Carrots.

SERIES.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XIX., . . .	8	I.	89.10	33.48	52.03	131.89	95.66	79.63
XIX., . . .	8	II.	94.42	46.40	77.87	154.59	99.91	91.20
XX., . . .	8	IV.	74.42	50.22	77.71	40.19	85.71	-
XX., . . .	8	V.	87.81	64.89	85.35	101.96	93.22	25.87
XX., . . .	8	VI.	83.73	43.77	86.53	82.06	93.04	9.95
XX., . . .	9	IV.	100.70	74.24	87.61	89.58	105.20	162.90
XX., . . .	9	V.	115.80	91.86	106.00	148.71	113.51	204.84
XX., . . .	9	VI.	135.05	96.15	127.94	197.52	130.76	228.23
Average, ...			100.95	64.40	89.05	129.47	104.75	114.66

Two different lots of carrots were fed. They averaged 87.64 per cent. water, and in dry matter contained 9.56 per cent. ash, 10.11 per cent. protein, 8.53 per cent. fiber, 70.71 per cent. extract matter and 1.09 per cent. fat. They are low in protein, fiber and fat, and quite high in ash and in extract matter.

In the first and second experiments they were fed in combination with hay, and constituted about 30 per cent. of the total dry matter which had a nutritive ratio of 1:10 to 1:13.6. In the third experiment they were fed together with hay and gluten feed, and composed about 15 per cent. of the dry matter of the ration, which had a nutritive ratio of 1:7.6. Sheep IV. in Series XX., Period 8, showed such a low rate of digestibility that the results were not included in the average. With this exception the coefficients resulting from the hay and carrot combination agree reasonably well, and show 88.76 per cent. of the dry matter to have been digested. The protein and extract matter are also shown to have been quite well assimilated. The fat is so small in amount that the results have no particular meaning. In most cases a high fiber digestibility is observed; in fact, more was apparently digested than was consumed.

Where the carrots were fed with hay and gluten feed more of the dry matter was apparently digested than was fed. Thus one observes coefficients of 117 for the dry matter, 107 protein, 145 fiber and 116 extract matter. This, it is believed, was due to the coefficients used for the digestibility of the basal ration, composed of hay and gluten feed. These coefficients for some reason averaged only 62.43 for the dry matter, as against 68.4, the average for all of the other experiments. If, however, one uses the average figure of 68.4, the coefficients for the dry matter of the carrots vary from 67.4 to 101.66.

The coefficients as a whole indicate that carrots were quite fully utilized, and that they seemed to improve the digestibility of the basal ration with which they were fed. It is proposed to study this matter more fully.

(*c*) *Mangels.*

Summary of Coefficients of Mangels.

Series.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XVIII.,	3	V.	86.90	1.55	41.21	103.45	95.79	–
XVIII.,	3	VI.	88.74	18.12	51.18	103.81	96.29	–
XVIII.,	6	V.	85.43	41.31	48.36	89.58	93.40	–
XVIII.,	6	VI.	87.20	52.36	63.00	85.31	93.67	–
Average,			87.07	30.58	50.94	95.54	94.76	–
Average of all previous trials (6),			84	–	59	78	94	–

Four single trials were carried out with one lot of mangels which contained 83.10 per cent. of water, — less than is found usually in this root. In the dry matter there was 6.10 per cent. ash, 5.84 per cent. protein, 6.38 per cent. fiber, 81.40 per cent. extract matter and .28 per cent. fat. The mangels were very low in protein, fiber and fat, and high in extract matter. They were fed in combination with hay only, and constituted from 40 to about 47 per cent. of the total dry matter of the combined ration, which had a nutritive ratio of 1:11 to 1:13. The coefficients are quite satisfactory, showing the dry matter to be 87, the protein 51 and the fiber and extract matter 95 per cent. digested. It is possible that the mangels improved the digestibility of the hay somewhat, but it is regretted that they were not fed also with a combination of hay and a protein concentrate in order to note if they would not have had a more pronounced effect.

(*d*) *Pumpkins.*

Summary of Coefficients of Entire Pumpkins.

Series.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XIX., . . .	6	I.	75.87	64.82	70.50	59.74	81.54	96.29
XIX., . . .	6	II.	89.32	63.93	80.69	86.30	98.12	96.87
XX., . . .	2	I.	81.62	70.96	67.89	65.20	90.84	89.27
XX., . . .	2	II.	88.23	62.99	76.20	83.59	96.40	91.76
XX., . . .	3	I.	78.80	68.35	83.63	47.80	86.30	88.10
XX., . . .	3	II.	75.41	49.82	82.57	46.23	83.83	84.69
XX., . . .	4	I.	75.57	76.91	74.81	38.49	83.82	94.23
Average, ...			80.69	65.40	76.61	61.05	88.69	91.60

Pumpkins minus Seeds and Connecting Tissue.

XIX., . . .	4	I.	109.23	105.13	92.55	137.52	108.99	101.44
XIX., . . .	4	II.	93.84	59.48	93.96	95.16	102.44	83.81
Average, ...			101.54	82.31	93.26	116.34	105.72	92.63

Two lots of pumpkins, grown on two different farms in successive years, were used. One lot was tested whole, and also without the seeds and connecting tissue. The whole pumpkins averaged 87.53 per cent. water, and the dry matter contained 7.74 per cent. ash, 15.60 per cent. protein, 15 per cent. fiber, 49.37 per cent. extract matter and 12.29 per cent. fat. The edible portion contained 94.58 per cent. water, and its dry matter consisted of 8.81 per cent. ash, 13.74 per cent. protein, 17.33 per cent. fiber, 57.56 per cent. extract matter and 2.56 per cent. fat.

Wider variations occur in the digestibility of the different ingredients by the two sheep than are desirable. In case of Series XX., Periods 3 and 4, where the pumpkins were fed with a basal ration of hay and gluten feed, the coefficients for the fiber, extract matter and fat appear to be lower than when the basal ration consisted of hay only. One would expect contrary results, for the combination of hay and pumpkins had a nutritive ratio of 1:9 to 1:11, and the hay, gluten feed and pumpkins a ratio of approximately 1:7.5. The lower digestibility of the pumpkins in the hay-gluten-feed-pumpkin ration may have been caused by the extra amount of total dry matter fed (approximately 100 grams daily).

The coefficients for the pumpkins minus the seeds are considerably higher, and, so far as one is able to judge from the results, indicate that the pumpkins had a favorable effect upon the digestibility of the hay. When the entire fruit was fed no seeds or parts of seeds were found in the feces.

In general, it may be said that the entire pumpkins appear to be fairly well digested, but not quite as fully as are mangels, turnips and carrots. Their relative feeding values will depend considerably upon their content of dry matter. The large percentage of fat in the pumpkin tends to increase slightly its feeding value pound for pound over most of the root crops.

(*e*) *Turnips.*

Summary of Coefficients of Turnips.

SERIES.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XVIII., . .	7	V.	88.78	55.34	70.15	87.75	95.48	56.90
XVIII., . .	7	VI.	89.17	51.38	81.08	75.55	96.64	75.86
Average, ...			88.98	53.36	75.62	81.65	96.06	66.38

One lot only of Swedish turnips was tested, which contained 86.21 per cent. water; the dry matter tested 7.33 per cent. ash, 9.58 per cent. protein, 10.99 per cent. fiber, 71.31 per cent. extract matter and .79 per cent. fat. They were rather richer in protein and fiber than mangels, and somewhat lower in carbohydrate matter. At the same time they may be regarded as carbohydrate in character. They were fed together with hay, and constituted 38 per cent. of the total ration, which had a nutritive ratio of 1:10.4. The results with the two sheep agree very closely, the sheep digesting 89 per cent. of the dry matter, 76 per cent. of the protein, 82 per cent. of the fiber and 96 per cent. of the starchy matter.

Comparative Summary of Coefficients for Roots and Vegetables.

	Water (Per Cent.).	DIGESTION COEFFICIENTS.						Digestible Organic Nutrients in 2,000 Pounds (Basis, 88 Per Cent. Water).
		Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	
Whole cabbage,	88	88	57	86	91	96	70	193
Carrots, . .	88	101	64	89	129	105	115	233
Mangels, . .	83	87	31	51	96	95	-	196
Turnips, . .	86	89	53	76	82	96	66	204
Pumpkins, .	88	81	65	77	61	89	92	212

The total dry matter of the carrots appears to be more fully digestible and the dry matter of the pumpkin less digestible than that of the mangels, turnips and cabbage, the coefficients of which are quite uniform. The protein shows a high and uniform digestibility excepting that contained in the mangels. The fiber — excepting in the pumpkins, with its hard shell and seed covering — is shown to be quite well digested, as is also the extract matter. The fat is not of much consequence excepting in the pumpkin, which contains over 12 per cent. with a high digestion coefficient. On a uniform moisture basis of 88 per cent., the total digestible organic nutrients (including the fat multiplied by 2.2) do not vary widely from each other, with the exception of the carrots, which merit further study.

Summary of Coefficients of Vegetable Ivory Meal.

SERIES.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XIX., ...	5	V.	84.43	44.35	-	55.01	93.27	-
XIX., ...	5	VI.	89.63	17.99	30.04	85.82	93.89	45.45
XX., ...	13	IV.	88.20	63.59	10.57	76.08	93.60	39.01
XX., ...	13	V.	98.96	94.01	34.61	120.48	99.99	60.28
XX., ...	13	VI.	101.71	44.24	41.70	129.22	102.28	31.91
XXI., ...	3	IV.	78.59	193.81	1.59	51.07	85.81	61.82
XXI., ...	3	V.	81.04	-	4.77	100.06	89.94	47.10
XXI., ...	3	VI.	84.03	90.95	6.04	66.45	91.98	58.70
Average, ...			88.33	78.42	18.47	85.52	93.84	49.18
Corn meal for comparison, . .			88	-	67	-	92	90

This material represents the sawdust or shavings from the vegetable ivory, or the corozo nut (*Phytelephas macrocarpa*). A complete report on its composition, digestibility and feeding value has been published elsewhere.[1] The details of the several digestion tests, however, were not given. The nut is used in the manufacture of buttons and similar materials; the residue is practically tasteless and of a tough, horny nature. Animals will not eat it when fed by itself, but usually consume it readily if mixed with one or more grains. It averaged in composition 10.76 per cent. water, and in dry matter 1.25 per cent. ash, 5.36 per cent. crude protein, 8.01 per cent. fiber, 84.37 per cent. extract matter and 1.01 per cent. fat. Its extract or carbohydrate matter is nearly all in the form of mannan, yielding mannose on hydrolysis.

The material in all cases was fed with 550 grams of hay and 150 grams of gluten feed as a basal ration, and constituted some 30 per cent. of the total ration.

A glance at the results show that the coefficients secured in Period 13 (hitherto unpublished) are noticeably above the others. This is believed to have been caused by the use of the coefficients secured for a basal ration of hay and gluten feed, which gave 62 as the digestibility of the dry matter as against 66 for the basal ration of hay and gluten feed employed in the other experiments. The average of the coefficients secured in Periods 5 and 3 (as published) gave 84 for the dry matter and 92 for the extract matter, and are believed to be more nearly correct.

The coefficients secured for the protein, fiber and fat are not surprising, in view of the smallness of the amounts present in the ivory meal in comparison with the total amounts of these ingredients consumed. The larger part of the ivory meal consists of carbohydrate matter, and it was quite well digested. How the mannan was decomposed in the digestive tract is not clear; it was found, however, to have largely disappeared in the feces. The ivory meal evidently is as fully digested as corn meal, and our published results of experiments with dairy animals demonstrate it to have considerable nutritive value.

Summary of Coefficients of Vinegar Grains.

SERIES.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XXII., . . .	9	IX.	54.77	–	62.91	47.02	50.92	84.20
XXII., . . .	9	XI.	55.01	–	59.28	50.59	52.63	88.08
XXII., . . .	10	IV.	65.60	29.08	69.47	60.92	54.71	89.30
XXII., . . .	10	VI.	67.48	–	66.00	73.87	65.60	68.70
Average, ...			60.70	–	64.42	58.10	55.97	82.57
Dried brewers' grains for comparison (5).			61	–	81	49	57	89

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[1] Beals and Lindsey: Journal of Agricultural Research, Vol. VII., No. 7.

Vinegar grains were put out by the Fleischmann Company, Chicago, and represent the residue in the manufacture of yeast, or possibly of yeast and distilled liquors. They tested 7.63 per cent. water, and the dry matter contained 2.54 per cent. ash, 20.39 per cent. protein, 20.12 per cent. fiber, 50.33 per cent. extract matter and 6.62 per cent. fat. They were fed together with hay to four sheep. For some reason Sheep IX. and XI. did not digest them as well as did Sheep IV. and VI. The average results from the four sheep show that in total digestible matter, fiber and extract they compare well with dried brewers' grains, although the protein of the latter is more completely utilized. They are certainly an addition to our supply of protein concentrates, and can be used in the grain ration in a similar way to dried brewers' grains.

Summary of Coefficients of New Bedford Garbage Tankage.

SERIES.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XXI., ...	8	IV.[1]	54.22	63.14	33.90	–	68.04	–
XXI., ...	8	V.	77.33	73.06	30.02	145.8	87.18	100.0
XXI., ...	8	VI.	81.12	74.22	45.18	116.8	92.01	147.0
Average, ...			79.22	73.64	37.6	131.3	89.6	123.5

[1] Excluded from average.

This tankage represents the garbage collected in the city of New Bedford which was treated by the so-called Cobwell process. Briefly stated, the method of treatment consists in removing, so far as possible, from the material as received, all glass, tin cans, banana and orange peel, after which the residue is placed in large iron tanks and treated with benzine to remove the fat, which process also takes out the larger part of the water. It is then run over conveyors, and any other objectionable material is removed, after which it is ground.

The tankage contained 8.53 per cent. water, and in dry matter 15.72 per cent. ash, 22.02 per cent. protein, 9.67 per cent. fiber, 50.92 per cent. extract matter and 1.67 per cent. fat. It was in good mechanical condition, was fed with hay and gluten feed, and constituted about 18 per cent. of the ration, which had a nutritive ratio of 1:7.

Sheep IV. digested the tankage poorly, and it has seemed wise to exclude the coefficients from the average of those secured with the other two sheep.

The protein was not well digested, which indicated its inferiority as compared with material derived from slaughterhouses. This was confirmed by subjecting the tankage to the action of the alkaline permanganate method for determining nitrogen availability, and the securing of an availability coefficient of 44.66. Any nitrogenous matter testing below 50 by this method is considered of poor quality. The extract matter was quite well utilized, and likewise the small amount of fat. The fiber for some reason appeared to be completely digested, which is not probable.

The non-nitrogenous matter of the tankage was quite well utilized, but the protein is likely to prove inferior to the better grades of animal or vegetable nitrogenous concentrates.

Summary of Coefficients of New Bedford Pig Meal.

Series.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XX., . . .	11	IV.	68.99	48.02	67.35	18.45	84.02	133.77
XX., . . .	11	VI.	69.29	40.96	71.39	26.18	83.40	142.88
Average, ...			69.14	44.49	69.37	22.32	83.71	138.33

This material according to the manufacturers was composed of 73 per cent. garbage tankage, 18 per cent. standard middlings, 7 per cent. prepared molasses feed and 2 per cent. linseed meal. It tested 8.80 per cent. water, and the dry material consisted of 19.65 per cent. ash, 23.59 per cent. protein, 9.15 per cent. fiber, 44.30 per cent. extract matter and 3.31 per cent. fat.

The sheep digested the entire mixture fairly well. Evidently the addition of the vegetable concentrates improved the digestibility of the total protein in the mixture. The fiber was poorly digested, but the extract matter and particularly the fat showed high coefficients.

It is quite reasonable to assume that garbage tankage is likely to vary considerably in quality.

Summary of Coefficients of Rowen.

Series.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XXII., . . .	15	XII.	60.81	34.23	60.39	68.12	63.37	30.01
XXII., . . .	15	XIII.	61.16	35.76	60.27	68.08	63.57	34.53
Average, ...			60.99	34.40	60.33	68.10	63.47	32.27
Average previous trials (12), .			65	–	70	66	65	47

Rowen represents the second growth of meadows, and contains in addition to the grasses a considerable admixture of clover. The samples tested contained 9.13 per cent. of water, and in dry matter showed 7.19

per cent. ash, 8.14 per cent. protein, 49.02 per cent. extract matter, 2.39 per cent. fat and 33.26 per cent. fiber. While of satisfactory appearance it was inferior in composition to the average, which has been shown to test 11.4 per cent. protein and 24.1 per cent. fiber on a 14 per cent. water basis.

The digestion tests agree exceedingly well, but confirm the analysis, showing it to be rather less digestible than the average of previous trials.

Summary of Coefficients of Soy Bean Hay.

SERIES.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XX., ...	7	V.	52.27	11.63	70.90	49.36	54.78	53.91
XX., ...	7	VI.	61.03	29.26	78.86	55.75	64.72	64.71
Average, ...			56.65	20.44	74.88	52.56	59.75	59.31
Average previous trials (4), .			60	–	73	57	64	44

The medium green soy beans were grown upon the station grounds, and were cut to put in the silo about the middle of September. They had not sufficiently matured to warrant their use as a seed crop. At the time of making the test the hay contained 11.73 per cent. of water, and, on a dry matter basis, 6.63 per cent. ash, 15.86 per cent. protein, 34.88 per cent. fiber, 40.56 per cent. extract matter and 2.07 per cent. fat. The tough, fibrous nature of the straw is in evidence in the high fiber content of the hay. Sheep V. was not able to digest the hay as well as Sheep VI. The results for the latter sheep agree fairly well with the average of the four other trials reported.

With the exception of the protein the ingredients in soy bean hay appear to be about equal in digestibility to those contained in average English hay. The higher digestibility of the protein is due to the presence of the beans. It is believed soy beans should be ensiled with corn rather than made into hay.

Summary of Coefficients of Stevens' "44" Dairy Ration.

SERIES.	Period.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XXII., ...	11	IV.	72.55	26.03	82.14	45.36	72.58	91.88
XXII., ...	11	VI.	68.58	–	77.23	55.01	69.23	71.08
Average, ...			70.57	26.03	79.69	50.19	70.91	81.48

The Stevens' "44" Dairy Ration is one of the numerous proprietary dairy rations offered in Massachusetts markets. It is claimed to be a mixture of a great variety of the most desirable grains and by-products. It had 8.94 per cent. water, and in dry matter 4.17 per cent. ash, 26.95 per cent. protein, 12.88 per cent. fiber, 49.56 per cent. extract matter and 6.44 per cent. fat. Its high fiber content indicated the presence of some unsatisfactory material, and this was confirmed by the digestion test. The mixture proved to be fairly well digested, but not equal in total digestibility to mixtures of bran, cottonseed meal, gluten feed and corn or hominy meal. The fiber digestibility was considerably below that secured for hay, while the extract matter was below what one would expect in high-grade material. The protein, on the other hand, was quite well digested.

Digestibility of Sudan Grass.

This grass (*Andropogon sorghum* var.) was introduced into the United States in 1909, and has been tried at this station for a number of years. A full report on its merits will be given elsewhere. The green material contained from 76.5 to 80.42 per cent. of water when cut, and the hay averaged 14.47 per cent. of water. On the basis of dry matter the two samples of green material averaged 6.84 per cent. ash, 13 per cent. crude protein, 29.10 per cent. fiber, 47.13 per cent. extract matter and 3.93 per cent. fat. The hay averaged in dry matter 8.93 per cent. ash, 13.85 per cent. crude protein, 33.85 per cent. fiber, 41.80 per cent. extract matter and 1.53 per cent. fat. The green material was fed with English hay, and the ration had a nutritive ratio of 1:8.3. The Sudan hay in three out of four experiments was fed exclusively, and had a nutritive ratio of 1:5.7.

Summary of Coefficients of Sudan Grass.

Series.	Period.	Sheep.	Condition of Grass.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
XXII.	17	XII.	Green, first crop (heading).	77.23	86.93	79.61	85.45	69.63	86.59
XXII.	17	XIII.	Green, first crop (heading).	70.84	39.96	79.16	77.97	68.97	80.34
Average, ...				74.04	63.45	79.39	81.71	69.30	83.47
XXII.	1	IV.	Green, second crop,	65.41	37.97	62.86	69.40	67.70	64.69
XXII.	1	VI.	Green, second crop,	65.09	24.30	68.07	69.42	67.69	58.51
Average, ...				65.25	31.14	65.47	69.41	67.70	61.60
XXII.	3	IV	Dry, second crop, .	59.99	45.07	58.13	73.62	54.35	35.63
XXII.	3	VI.	Dry, second crop,	59.37	40.27	61.40	72.76	53.52	35.32
Average, ...				59.68	42.67	59.77	73.19	53.94	35.48

In Period 17, first crop, Sheep XII. digested the material rather better than Sheep XIII.

In Period 1 the green material, second crop, scarcely in head, was cut and fed in September. At the same time, some of it was made into hay and fed later. The total dry matter of the hay was over 4 per cent. less digestible than the same material fed green. Strange to say, the fiber showed a somewhat higher digestibility in the hay, while the extract matter was noticeably less digestible. As might have been expected, the fat (ether extract) showed a lower digestibility in the hay, due probably to the fact that the sheep were able more thoroughly to extract such substances out of the green plant. For some reason the sheep digested the second crop (green) less fully than they did the first. The latter was cut in 1917, and the former in September, 1916. Whether the lessened digestibility was due to the climatic variations prevailing in two different years, or because a second growth was actually not as digestible as the first, it is not possible to say. The average of the coefficients of the two lots of green Sudan grass follows, together with green barnyard millet, sorghum and corn for comparison.

Average Coefficients for Comparison.

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sudan grass, . . .	2	4	69.64	47.30	72.42	75.56	68.50	72.54
Barnyard millet (blossom),	3	6	70.00	56.00	65.00	73.00	71.00	58.00
Sorghum (past blossom), .	2	4	65.00	42.00	44.00	55.00	73.00	64.00
Corn fodder (dent) milk, .	7	17	70.00	39.00	62.00	64.00	77.00	76.00

The above comparison indicates that Sudan grass in digestibility is fully equal to other important green feeds.

Summary of Coefficients of Sudan Hay.

Series.	Period.	Sheep.	Character of Hay.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XXII.	7	IX.	Before heading, first crop.	56.25	55.92	56.63	66.38	49.24	23.01
XXII.	7	XII.	Before heading, first crop.	55.14	51.42	55.22	66.42	48.74	10.38
XXII.	7	XIII.	Before heading, first crop.	57.15	56.93	57.83	66.82	50.51	19.62
Average, ...				56.18	54.76	56.56	66.54	49.50	17.67

Summary of Coefficients of Sudan Hay — Concluded.

Series.	Period.	Sheep.	Character of Hay.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XXII.	6	IX.	Heading, first crop,	59.19	55.48	64.36	68.40	51.57	28.00
XXII.	4	IX.	Full blossom, first crop.	58.11	53.50	62.37	66.33	51.48	42.73
XXII.	4	XI.	Full blossom, first crop.	54.72	42.25	47.73	64.80	48.39	34.61
Average, ...				56.42	47.88	55.05	65.57	49.94	38.67
XXII.	3	IV.	Heading, second crop.	59.99	45.07	58.13	73.62	54.35	35.63
XXII.	3	VI.	Heading, second crop.	59.37	40.27	61.40	72.76	53.52	35.32
Average, ...				59.68	42.67	59.77	73.19	53.94	35.48
Average of all of above, ...				57.49	50.11	57.96	68.19	50.98	28.66

Results at Texas Experiment Station.

Series.	Period.	Sheep.	Character of Hay.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
–	39	1and2	Headed, . . .	–	30.00	17.70	63.10	57.60	48.70
–	60	1and2	Full tassel, . .	–	23.50	58.30	58.60	41.80	45.20
–	62	1and2	Headed, blooming,.	–	15.00	64.20	60.20	52.60	61.10
–	73	1and2	Late, mixed with crab grass.	–	32.20	57.30	62.80	59.60	61.10
Average, ...				–	24.80	49.40	61.20	52.90	54.00
Timothy hay, for comparison, ...				55	39.00	48.00	50.00	62.00	50.00
Barnyard millet, well headed, ...				57	63.00	64.00	62.00	52.00	46.00

In the above trials an effort was made to note the digestibility of Sudan grass cut at successive stages of growth. The results do not indicate any particular difference. The second cutting of hay appeared to be more digestible than the first. Whether this would hold true in all cases is of course not established. It is just the opposite from the results secured with the green Sudan grass. The probability is that much will depend upon the climatic conditions prevailing during growth. If the weather should be warm, with plenty of sunlight and moisture, it is possible that the second growth would fully equal and perhaps exceed the first growth in digestibility.

Results recently reported[1] from the Texas Experiment Station are somewhat below those secured by us, at least in case of the fiber. If one should eliminate the protein coefficient of Period 39 the remaining protein coefficients would be some two points above the Massachusetts figure.

In all of the trials one notes particularly the high digestibility of the fiber and the low coefficients secured for the extract matter and fat. This holds true also for the millet. The digestibility of Sudan grass is shown to be above that for timothy, and equal to barnyard millet. The difficulty in curing satisfactorily the coarse grasses, of which Sudan and millet are examples, render them less satisfactory for hay than that obtained from the finer grasses.

Digestibility of Sweet Clover.

Sweet clover (*Melilotus Alba*) is a biennial legume found quite widely distributed in southern Canada and the United States. The two samples used were grown on the experiment station grounds. The clover was fed green to the sheep, beginning about June 12 and ending June 26. At the close of the trials the clover was budding to early blossom, and the lower portion of the stalks was woody. The two samples averaged 84.50 per cent. of water, and in dry matter contained 7.08 per cent. ash, 19.40 per cent. protein, 30.29 per cent. fiber, 40.10 per cent. extract matter and 3.13 per cent. ash. The green clover was fed with hay, and the rations had an average nutritive ratio of 1:6.4.

Summary of Coefficients of Sweet Clover.

Series.	Period.	Sheep.	Condition of Clover.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XXI.	14	IV.	Early blossom, .	64.80	47.93	75.29	60.56	64.07	49.91
XXI.	14	VI.	Early blossom, .	73.30	48.96	78.58	78.58	74.00	50.28
Average, ...				69.05	48.44	76.93	69.57	69.03	50.10
XXII.	16	IX.	Budding, . .	66.67	–	76.44	47.60	65.96	43.22
XXII.	16	XI.	Budding, . .	72.61	–	81.98	52.29	71.00	61.34
Average, ...				69.64	–	79.21	49.95	68.48	52.28
Average of both samples, ...				69.45	48.45	78.07	59.76	68.76	51.19
Alfalfa[2] for comparison, ...				61.00	–	74.00	42.00	72.00	38.00
Clover[2] for comparison, ...				66.00	–	67.00	53.00	78.00	65.00

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[1] Bulletin No. 203, 1916.

[2] Henry and Morrison.

Sweet Clover Hay, Wyoming Station, Bulletin No. 78.

Series.	Period.	Sheep.	Condition of Clover.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
–	XIV.	1, 2, 3	Rank, late cut, .	60.88	65.79	75.46	33.63	72.04	30.94
Alfalfa[1] hay for comparison, ...				60.00	45.00	74.00	46.00	70.00	28.00
Clover[1] hay for comparison, ...				62.00	58.00	61.00	53.00	68.00	54.00

[1] Massachusetts Station.

Sheep IV. in Series XXI., and Sheep IX. in Series XXII. did not seem able to digest the clover as well as the other two sheep. The slight variation in the stage of growth of the clover appeared to be without influence on its digestibility. The young sheep IX. and XI. did not digest the fiber as well as did the old sheep IV. and VI. Sweet clover cut previous to blooming appeared to be quite well utilized, and showed rather higher coefficients than those for alfalfa or clover cut in bloom. The results of the Wyoming Station with sweet clover hay cut at an advanced stage of growth indicate that with the exception of the fiber it is as fully digestible as either alfalfa or clover hay.

TABLE VI. — COMPLETE SUMMARY OF THE AVERAGES OF ALL COEFFICIENTS, ARRANGED ALPHABETICALLY.

RATION.	Number of Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Alfalfa, ...	4	57.74	42.61	71.78	46.40	66.12	23.62
Cabbage (entire), ...	2	87.92	56.97	86.13	91.03	95.86	69.72
Cabbage (heads), ...	2	97.83	77.29	76.54	112.27	102.32	42.67
Cabbage (leaves), ...	2	74.12	44.97	63.80	78.23	84.34	37.39
Carrots, ...	8	100.95	64.40	89.05	129.47	104.75	114.66
Corn bran, ...	5	80.59	–	43.77	75.92	85.15	65.53
Distillers' grains, ...	4	66.54	36.31	77.05	44.44	67.38	83.70
English hay — basal, ...	23	59.47	36.31	49.78	64.10	62.35	46.34
English hay and gluten feed — basal,	14	66.59	33.25	66.39	67.75	69.91	51.89
English hay, potato starch and gluten meal (Diamond) — basal.	6	73.27	20.16	72.98	63.54	80.67	37.16
English hay and wheat gluten flour (*to note effect of the flour*).	5	58.00	43.00	44.00	62.00	61.00	43.00
Feterita, ...	2	74.51	–	50.67	–	87.76	58.70
Gluten feed, ...	16	91.59	152.58	85.44	142.41	93.77	64.41

TABLE VI. — COMPLETE SUMMARY OF THE AVERAGES OF ALL COEFFICIENTS, ARRANGED ALPHABETICALLY — *Concluded.*

RATION.	Number of Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Gluten meal (Diamond),[1]	6	86.00	–	85.00	100.00	93.00	–
Mangels,	4	87.07	30.58	50.94	95.54	94.76	–
New Bedford garbage tankage,	3	79.22	73.64	37.60	131.30	89.60	123.50
New Bedford pig meal,	2	69.14	44.49	69.37	22.32	83.71	138.33
Pumpkins (entire),	7	80.69	65.40	76.61	61.05	88.69	91.60
Pumpkins (seeds removed),	2	101.54	82.31	93.26	116.34	105.72	92.63
Rowen,	2	60.99	34.40	60.33	68.10	63.47	32.27
Soy bean hay,	2	56.65	20.44	74.88	52.56	59.75	59.31
Stevens' "44" Dairy Ration,	2	70.57	26.03	79.69	50.19	70.91	81.48
Sudan grass (green),	4	69.64	47.30	72.42	75.56	68.50	72.54
Sudan hay,	8	57.49	50.11	57.96	68.19	50.98	28.66
Sweet clover (green),	4	69.45	48.45	78.07	57.76	68.76	51.19
Turnips,	2	88.98	53.36	75.62	81.65	96.06	66.38
Vegetable ivory meal,	8	88.33	78.42	18.47	85.52	93.84	49.18
Vinegar grains,	4	60.70	–	64.42	58.10	55.97	82.57

[1] See page 312.

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Public Document No. 31

THE MASSACHUSETTS AGRICULTURAL COLLEGE

ANNUAL REPORT

OF THE

EXTENSION SERVICE

WILLIAM D. HURD, *Director*

FOR THE YEAR ENDING NOVEMBER 30, 1917

BEING PART V. OF THE FIFTY-FIFTH ANNUAL REPORT OF THE
MASSACHUSETTS AGRICULTURAL COLLEGE

Co-operative Extension Work in Agriculture and Home Economics, State of Massachusetts

THE MASSACHUSETTS AGRICULTURAL COLLEGE AND THE UNITED STATES
DEPARTMENT OF AGRICULTURE CO-OPERATING

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1918

Publication of this Document
approved by the
Supervisor of Administration.

The Commonwealth of Massachusetts.

Massachusetts Agricultural College,
Amherst, Jan. 1, 1918.

To His Excellency Samuel W. McCall.

Sir: — On behalf of the trustees of the Massachusetts Agricultural College I have the honor to transmit herewith, to Your Excellency and the Honorable Council, Part V. of the fifty-fifth annual report of the trustees, this being the annual report of the Extension Service for the year 1917.

I am, very respectfully, your obedient servant,

KENYON L. BUTTERFIELD,
President.

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MASSACHUSETTS AGRICULTURAL COLLEGE EXTENSION SERVICE.

ORGANIZATION FOR 1917.

Trustee Committee on Extension Service.

Elmer D. Howe, Marlborough, *Chairman.*
Harold L. Frost, Arlington.
George H. Ellis, Boston.
Davis R. Dewey, Boston.
Wilfrid Wheeler, Boston.
John F. Gannon, Worcester.

Member Ex Officio.

President Kenyon L. Butterfield, Amherst, Mass.

The Extension Service Staff.

William D. Hurd, *Director of the Extension Service.*
Austin D. Kilham, *Acting Director.*
B. W. Shaper,[1] *Assistant to the Director.*
L. Wayne Arny, *Supervisor of Correspondence Courses and Extension Editor.*
Gardner Boyd, *Emergency Assistant State Leader of Junior Extension Work.*
Wesley H. Bronson,[2] *Extension Assistant Professor in Farm Demonstration.*
Walter W. Chenoweth, *Extension Professor of Food Preservation.*
Laura Comstock, *Extension Professor of Home Economics.*
E. Farnham Damon, *Extension Associate Professor of Agricultural Economics and Assistant County Agent Leader.*
Harriet L. B. Darling, *Emergency Assistant Home Demonstration Leader, Urban.*
A. Lawrence Dean, *Extension Instructor in Poultry Club Work.*
William L. Doran, *Extension Instructor in Plant Diseases.*
George L. Farley, *Supervisor of Junior Extension Work.*
Erwin H. Forbush,[1] *Supervisor of Correspondence Courses.*
Laura R. Gifford, *Emergency Assistant Home Demonstration Leader, Rural.*
N. May Gunderson,[1] *Emergency Assistant Home Demonstration Leader, Rural.*
H. E. Haslett, *Extension Instructor in Sheep Husbandry.*
Roswell W. Henninger,[2] *Extension Instructor in Charge Poultry Club Work.*
Alfred G. Lunn, *Extension Assistant Professor of Poultry Husbandry.*
E. L. Morgan, *Extension Professor of Community Planning.*
Ethel H. Nash,[1] *Extension Instructor in Agricultural Education.*
Helen M. Norris, *Extension Instructor in Agricultural Education.*
Sumner R. Parker, *Extension Professor of Rural Organization and County Agent Leader.*
Victor A. Rice, *Extension Instructor in Pig Club Work.*
Mabel C. Rogers, *Emergency Assistant Home Demonstration Leader, Rural.*
Antoinette Roof, *Emergency State Home Demonstration Leader, Urban.*

---

[1] Resigned.

[2] On leave of absence.

Marie Sayles,[1] *Extension Assistant Professor of Home Economics.*
F. A. Cushing Smith,[1] *Extension Assistant Professor of Landscape Gardening.*
Mrs. F. A. Cushing Smith, *Extension Instructor in Home Economics.*
Frances Stern, *Specialist in Food for Industrial Workers.*
Andrew S. Thomson, *in Charge of Short Courses.*
William F. Turner, *Extension Assistant Professor of Animal Husbandry.*
Eudora F. Tuttle, *Emergency Assistant Home Demonstration Leader, Rural.*
R. A. VanMeter, *Extension Instructor in Pomology.*

Heads of Departments devoting Part Time to Extension Work.

Alexander E. Cance, *Agricultural Economics.*
James A. Foord, *Farm Administration.*
Burton N. Gates, *Beekeeping.*
John C. Graham, *Poultry Husbandry.*
Charles R. Green, *Librarian of the College.*
William P. B. Lockwood, *Dairying.*
Fred C. Sears, *Pomology.*
Frank A. Waugh, *Landscape Gardening.*

Clerical Staff.

Elbert L. Arnold,[2] *Chief Clerk, Extension Service.*
Ella B. Baldwin, *Clerk, Extension Service.*
Mabel R. Case, *Collaborating Clerk.*
Doris Clark,[2] *Stenographer, Junior Extension Work.*
Cassie Clark, *Clerk, Extension Service.*
Hazel A. Dewar, *Stenographer, Division of Agriculture.*
Margaret Evens, *Clerk, Extension Service.*
Grace E. Gallond, *Clerk, Department of Dairying.*
Cora B. Grover, *Clerk, Director's Office.*
Lillian S. Hadfield, *Clerk, Junior Extension Work.*
Laura Hager, *Clerk, Department of Agricultural Economics.*
Helena K. Keiber,[2] *Stenographer, Extension Service.*
Clarence A. Kendall,[2] *Clerk, Extension Service.*
Ethel L. Kennedy, *Clerk, Extension Service.*
Gladys I. Miner, *Stenographer, Extension Service.*
Elizabeth Mooney,[3] *Stenographer, Department of Poultry Husbandry.*
Hazel Parker, *Stenographer, Division of Horticulture.*
Ethelyn Streeter,[3] *Stenographer, Division of Horticulture.*
Flora E. Torrey, *Clerk, Department of Farm Administration.*
Doris Tower, *Stenographer, Department of Poultry Husbandry.*
Burton C. Whidden, *Chief Clerk, Extension Service.*

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[1] On leave of absence. [2] Resigned. [3] Transferred from Extension Service.

ANNUAL REPORT OF THE EXTENSION SERVICE

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

HISTORY AND ORGANIZATION.

Ever since the organization of the Massachusetts Agricultural College its staff of teachers and research workers have been called upon to do a great deal of extension work. The number of calls have multiplied greatly during the last fifteen or twenty years.

A definite plan for organizing the extension work of the college was begun Sept. 1, 1909, under an appropriation of the Legislature of that year which provided funds for the support of short courses.

The purpose of the Extension Service is to provide "instruction in improved methods of agricultural production and welfare of rural population . . . for the people not enrolled as regular students in educational institutions."

"It is a permanent system of practical education for farming people, outside of schools, conducted according to well-matured plans, by public officers for the benefit of all the people."

The work has been much in demand, and has grown rapidly. Recognizing the need, and in order to satisfy the demand, the State has increased the appropriations from time to time.

The Extension Service of the Massachusetts Agricultural College represents the whole institution — all departments and individuals — at work doing what it can to build up the industrial, and especially the rural, life of the Commonwealth.

Through the Extension Service an attempt is made to carry the teachings of the college, and the results of the research work of this and other stations and scientific laboratories, out to all the people of the State who may desire this instruction. The methods of doing this are described in the reports from the several extension specialists, which may be found farther on in this report.

Every effort is made to co-ordinate the teaching, the research work and the extension work of the college so that they will all articulate and function together in developing and maintaining a well-defined institutional policy.

The type of organization which has been developed at this college conforms in the main to that recommended by the Association of Agricultural Colleges and Experiment Stations, the United States Department of Agriculture and prominent educators of this and other countries. Similar organizations are maintained in practically all of the other agricultural colleges and State universities, many of which, in fact, have patterned their extension divisions after our organization.

The war has brought many changes in the personnel and the work of the Extension Service, and these began long before war was declared. Every effort has been made to meet the ever-changing conditions that have confronted us. Plans developed so rapidly and the changes came so fast that it was very hard to do things in as substantial a way as might have been desired. In reviewing the year's work, however, we feel that in the main the task was well done, and that every worker did his part as well as possible under the conditions.

ADMINISTRATION.

The administration of the extension work is vested in a director of the Extension Service, who is responsible directly to the president of the college.

For purposes of administration the Massachusetts Agricultural College is organized into the following main divisions: —

1. Academic work: (*a*) undergraduate instruction (with a dean in charge); (*b*) graduate work (with a director in charge).
2. Experiment station (with a director in charge).
3. Extension Service (with a director in charge).

These positions are co-ordinate, each officer being directly responsible to the president of the college.

A committee on Extension Service organization and policy of the Board of Trustees holds several meetings each year, and considers all plans for work, appropriations, etc. The action of this committee is submitted to the full Board of Trustees for ratification or modification.

The college cabinet, which is made up of certain of the administrative officers of the institution, usually passes on matters of general policy before these are submitted to the trustees.

The bulk of the extension work is carried on by extension specialists, who, by training, experience, disposition and other qualifications, are especially well fitted to do this type of teaching. In addition, every representative of the institution is expected to render to the people of the Commonwealth whatever service he may be able without impairing his ability to accomplish consistently good work in his own particular field.

Extension specialists covering general lines of work are responsible to the director of the Extension Service. In other lines, where the work is specialized and technical in character, the work is organized in the proper departments of the college, the extension specialists being responsible to the head of the department for the subject-matter taught, and to the director of the Extension Service for the organization and carrying out of his particular line of work. Frequent conferences between the head of the department, the extension specialist and the director afford opportunity for discussion of the work, laying of plans, etc. This type of organization avoids setting up separate staffs with consequent conflict and misunderstanding, and maintains a proper departmental unity throughout the institution.

Conferences of the entire Extension Service staff are held to discuss matters of general importance and interest.

All extension work is on a written project basis, agreed to by the department concerned and the director; and, in case outside organizations are involved, by these organizations and the college.

The director of the Extension Service acts as a joint representative of the United States Department of Agriculture and the college where Federal funds are used, or in co-operative projects between these two organizations.

Weekly reports of work done and that contemplated are made to the director by extension specialists. At the beginning of each fiscal year a detailed apportionment of funds is made for projects, and this must be approved by the trustees. All supplies, equipment, etc., are purchased on requisitions approved by the director and the treasurer of the college. Monthly reports on Extension Service funds are rendered by the treasurer of the college to the director. All bills, traveling expenses for approved trips, etc., are approved by the director before being paid by the treasurer. Accounts are checked by an auditor representing the trustees each month, and by the State Auditor's office twice yearly. Smith-Lever and United States Department of Agriculture Co-operative Demonstration funds are also audited by a representative of the United States Department of Agriculture after the close of each fiscal year.

SOME PROMINENT FEATURES OF THE WORK DURING 1917.

Several significant things connected with the work suggest themselves as being worthy of special mention.

1. *Changes in Staff.* — Both permanent and temporary changes have been made in our staff in the past year. Director Hurd, who is on leave of absence until next July, is serving in Washington as special assistant in the office of the Secretary of Agriculture. Prof. Austin D. Kilham is acting director during Professor Hurd's absence. The assistant director resigned early in the year, and his place was taken by an assistant to the director. Four members of our staff have been granted leaves of absence to enable them to do war work.

Capable extension workers are becoming very scarce, and it is becoming more and more difficult to fill either temporary or permanent positions.

2. *Co-operative Work with the United States Department of Agriculture.* — Relationships with the United States Department of Agriculture have been strengthened. Several new co-operative projects have been undertaken with the department. Many of these projects are temporary in character because they are maintained on emergency funds which are not available after June 30, 1918. New projects are: (1) urban emergency home demonstration work; (2) rural emergency home demonstration work; (3) emergency county agricultural agent work; (4) emergency junior extension work; (5) truck crops disease work; (6) soft cheese demonstration work; (7) sheep production.

3. *Co-operation with Other Agencies.* — During the past year we have maintained very pleasing co-operative relationships with all of the organizations mentioned in our annual report of last year. The most noteworthy additions to this list are the Massachusetts Committee on Public Safety and the State Food Administration with their subordinate committees. Immediately upon the formation of the committee on food production and conservation of the Massachusetts Committee on Public Safety, the Extension Service as a part of the college was placed at the disposal of the committee. Every member of the Extension Service helped the work of the committee in some way. A few members of the Extension Service devoted several months of their time entirely to the work with the Committee on Public Safety. The relationships have been most pleasing and gratifying.

4. *County Agent Work.* — We have now completed the skeleton organization of the farm bureau work, as every agricultural county of the State now has its farm bureau organization. The farm bureaus in Middlesex, Dukes and Nantucket Counties have been organized in the past year. The Middlesex County Farm Bureau has a staff consisting of a secretary, a county agricultural agent, a home demonstration agent, and a boys' and girls' club worker. The Dukes and Nantucket Farm Bureaus have joined to employ two workers, — a county agricultural agent and a home demonstration agent. The organization and the preliminary work of the farm bureaus in Dukes and Nantucket were materially aided by the Massachusetts Committee on Public Safety.

Practically all of the farm bureaus have been strengthened by the addition of permanent or emergency workers. The Massachusetts Committee on Public Safety (by furnishing funds to carry on temporary work) helped at a time during the summer when pressure was urgent and when funds could not be obtained elsewhere. Soon after the emergency funds of the United States Department of Agriculture became available, in August, some of this support was dropped. A very important portion of the county agent work is still supported by the Massachusetts Committee on Public Safety.

The marketing of the products of our farms is taking more and more of the time of the county agents. In order to relieve the situation four assistants have been appointed to assist the county agents. These additional men are especially trained in marketing work, and are under the leadership of an assistant State leader.

5. *Rural Home Economics.* — Our regular rural home economics work has been speeded up in an endeavor to meet the present emergency. Early in the year three emergency workers were employed who demonstrate throughout the State. Plans were somewhat disorganized by the absence of Miss Comstock during the summer and the loss of Miss Sayles after the 1st of October.

Upon the passage of the emergency food bill the three temporary workers were placed on United States Department of Agriculture funds and were made assistants to Miss Comstock as State leader of rural home demonstration work.

The organization of the county home demonstration work now takes the greater part of the State leader's time. With the emergency work that is now necessary it is not possible for all of the organization undertakings to be carried out. A permanent assistant State leader should be appointed. With the rapid development of home demonstration work in the farm bureaus it is highly important that we obtain high-class specialists for this field. A specialist is needed in sewing and one in household management.

6. *Urban Home Demonstration Work.* — Immediately upon the passage of this bill Miss Antoinette Roof was appointed State leader of home demonstration agents (urban). Three assistants were also appointed.

Two difficulties at once presented themselves: first, to find properly qualified city leaders; second, to secure co-operation and financial support in the various cities.

More than 50 candidates were interviewed to secure the present force of 17 workers. Of this number, 2 are assistants to the State leader, 11 are city leaders, and 3 are assistant city leaders.

From the fact that eleven cities have been found in so short a time that are willing to give financial aid to this work, we feel that there is a real demand for it.

Special attention has been given to the organization of the work in each city. In most cases an executive committee has been appointed for each city, with local committees in each district. The city leader finds many organizations with which to co-operate, and in most cases finds many volunteer leaders who have had training in home economics or who have special qualifications because of their nationality.

In the future the organization of the work in the cities should be strengthened and better co-operation secured with all existing agencies. Better financial arrangements will have to be made if the work is to be permanent. Extension schools should be held to train local leaders.

The funds should be reapportioned for this undertaking early in January, and detailed plans made for the continuance of this work after June 30.

7. *Junior Extension Work.* — A large amount of extra war work was done by the boys' and girls' clubs. Special effort was made to increase the interest in these clubs by our workers. They were aided by special assistants employed in co-operation with the Massachusetts Committee on Public Safety. Upon the passage of the Federal war emergency act funds were made available which permitted the employment of State workers on a more permanent basis.

8. *Special Campaigns.* — In order to meet the unusual situation, several special campaigns were carried on. Among the most successful was the poultry campaign, which was developed by our poultry department in co-operation with the Massachusetts Committee on Public Safety and several other organizations. Reports indicate that these campaigns were very successful.

9. *Food Preservation.* — Previous to 1917 this very important activity was carried on in a very meager way under the pomology extension project. Early in the present year Professor Chenoweth developed this as part of the campus mobilization work. Material aid was given to community canning and evaporating centers, schools for leaders were held at the college, and schools and lectures were given throughout the State. Plans are under way to carry this work on in a very practical way during the next year.

10. *Additional Offices and Equipment.* — In spite of the large addition to our force no additional office space has been acquired in connection with the headquarters of the extension work. A small amount of necessary office equipment has been provided for the use of our emergency employees.

A number of charts, photographs and lantern slides have been added to our equipment. A considerable amount of new equipment for use at fairs and in demonstration work has been acquired. Most of this new material has been used in connection with demonstrations of canning, evaporating and other similar emergency work.

PROJECT REPORTS.

Rural Home Economics.

The regular work of the department was carried on much as in previous years until May 1, when the urgent emergency work required the employment of two other helpers. Miss Mabel C. Rogers and Miss Eudora F. Tuttle were engaged as assistants. Three more were secured for the summer school held on the campus, one of whom, Miss N. May Gunderson, was retained for regular work. Miss Rogers was later transferred to city home economics work.

Miss Laura Comstock, State home demonstration agent leader, was granted leave of absence for five months on account of illness. During that time the work was very successfully carried on by Miss Marie Sayles as acting State leader. The State leader returned in September. In October Miss Sayles was granted leave of absence until July 1, 1918, to assist in the home economics organization work in the States Relation Service of the United States Department of Agriculture.

Upon the passage by Congress of the emergency food production and conservation bill, the States Relations Service cooperated with the Extension Service by aiding in the employment of emergency workers. Miss Tuttle and Miss Gunderson were made assistant State leaders. In September Miss Laura Gifford, a third emergency assistant State leader, was appointed.

The organization of the county home demonstration work has occupied the greater part of the State leader's time. At the time of the last annual report four counties were organized for this work. Within the past year eight more workers have been added. Every county in the State, excepting Suffolk County, now employs a county home demonstration agent. Dukes and Nantucket Counties are combined under the supervision of one agent.

Besides the regular annual conference of the county home demonstration agents, which met at the college in December, two other conferences have been held during the year. The first of these, in June, was to plan for the summer work in production and conservation; the other, in November, was for the purpose of planning the winter extension schools.

While the counties have individual problems which have received attention, a general program of work was prepared at the annual conference of home demonstration agents, and has been carried out in each county. This program provided for special emphasis upon the subjects of household management, health, meal planning, food preservation and children's diets.

During the winter ten extension schools of one week each were held at various points in the State. These were conducted in the same manner as in previous years, a new feature being introduced, however, in the follow-up work. The members of each school were asked to undertake some one specific branch of the work for the year. Under this plan, local work has been done on the school lunch, securing home economics literature for the town library, and local health problems. A goodly number of members undertook individual home work along the lines of instruction in the school.

The usual correspondence groups were organized for food study. Each group was visited twice and the work was supervised according to local needs. To meet the emergency needs for conservation this course has been revised for the coming year.

The last week of March the usual farmers' week program was given on the campus. One day's program should have special mention. It included an able discussion of the grades and uses of household linens by Mrs. Mary S. Woolman, and health talks by Dr. J. E. Goldthwait and Dr. Evangeline W. Young.

The college co-operated with the States Relations Service in a conference of home economics workers of the northeastern section, including New England, New York, Pennsylvania, New Jersey and Delaware. This meeting was held in Boston in March.

During the summer months 71 extension schools of one day's and two days' duration were held throughout the State. The programs for these included demonstrations and lectures on canning, on drying and storage, and on meal planning. While no statement can be made as to the actual results of these schools, the attendance and interest were most encouraging.

In September and October college workers in home economics attended nine fairs in the State, giving canning demonstrations and presenting exhibits of meal planning, proper school lunches, fireless cooker and iceless refrigerator.

Co-operation with various State organizations has been a prominent feature of the year's work. The State leader of home demonstration agents has acted in an advisory capacity with committees of the Massachusetts Branch of the National Civic Federation, the New England Home Economics Association, the Massachusetts Federation of Women's Clubs, and the food conservation committee of the State Public Safety Committee. These organizations have all been more or less closely allied with the work of the women's committee of the Council of National Defence and with the Massachusetts Food Administration. It has been the purpose of these various organizations so to co-ordinate their enterprises that there may be the least possible overlapping of work and fields of endeavor.

Considerable emphasis has been laid during the year upon the training of local leaders. For this purpose the college offered courses on the campus during the time of the regular summer session. These included instruction in canning, drying and storage of fruits and vegetables. Another and more general course was offered in November, stressing especially other forms of food conservation rather than drying and canning.

In addition, a general course in home economics, looking to the training of local leaders, is being given for the first time to select groups in Mt. Holyoke and Smith colleges.

Several emergency bulletins on home economics and allied subjects have been published: "Community Canning and Evaporating," "Evaporating and Drying," "Methods of Saving Fats," "Canning of Fruits and Vegetables," "Preparation Wastes, Table Wastes, Storage Wastes," "Fruit Products," the "Home Vegetable Storage," "How to Save Wheat Flour."

In addition to the general and emergency work as outlined, the workers have met, in so far as possible, the calls for individual lectures, demonstrations and conferences.

STATISTICAL SUMMARY.

NAME OF ACTIVITY.	Number.	Attendance.	Number registered.
Conferences: —			
County agents,	58	85	-
County Home Economics Council,	34	286	-
County organization,	68	1,630	-
Miscellaneous,	100	951	-
Extension schools,	10	2,973	-
Food demonstrations,	20	1,602	-
Lecture demonstrations,	34	2,331	-
School lunches organized,	16	-	-
Farmers' week,	-	-	-
Summer school,	-	603	-
Refused invitations,	49	68	-

Emergency Work.

Emergency conferences,	52	714	-
Canning schools: —			
Two-day,	7	3,411	-
One-day,	64	6,519	-
School for leaders: —			
Canning,	3	274	79
Home conservation,	1	321	29
Mt. Holyoke College,	1	240	26
Smith College,	1	27	27
Fairs,	9	5,460	-

Emergency State Home Demonstration Work (Urban).

Upon the passage of the emergency food production and conservation bill, being H. R. Bill 4188, the State Relations Service established, in co-operation with the college, emergency work in cities along the same lines as the rural extension work in home economics. For the first time preparation was made to help the women in the cities to meet intelligently the difficulties of the food situation.

Immediately upon appointment Miss Roof began a search for emergency home economics workers. More than 50 candidates were interviewed to secure the present force of 17 workers. Of this number, 2 are assistants to the State leader; 11 are city leaders; and 3 are assistant city leaders. This record shows that 11 cities have accepted the offer of the government to pay the salary of the city leader, provided the city will vote the money to meet the local expenses. Where the city has a population of more than 100,000, $2,000 has been voted; where the population is less than 100,000, $1,000 has been voted.

The organization for city work consists of an executive committee, with local committees in each district. The city leader works through existing organizations and trains volunteer leaders for special work.

Much work has been done for food conservation in cities by volunteer committees, but wherever the plan of organization under a city leader has been presented, there has been a keen interest and quick response from such committees. The need is for some one to direct and guide the volunteer workers, and to suggest new fields of activity. For this reason the city leaders should be well-trained women with large practical experience.

In two counties the city work has been made a part of the county organization, while in the other counties the direct support has been given by the committees of public safety and the women's committees on food conservation.

We have had hearty co-operation, also, from the State Committee on Food Conservation, the women's unit of the Council of National Defence, the National Civic Federation, the Municipal League, Chambers of Commerce, Associated Charities, Social Unions, Parent-Teachers' Associations, schools, church organizations, private clubs, large department stores and grocery stores.

There seems to be a great willingness to unify and centralize the work on food education through the city leader.

The city work is so new that plans of organization are still not complete, but we are looking forward to the gradual development of the district system. Through this system the complex city problem may be studied in small units. This is especially applicable to cities with a foreign population, where there must be a unified effort to learn the food habits of these people in order that we may make an effective contribution through a knowledge of their needs and their interests. An interesting beginning has already been made through social workers and teachers of domestic science in schools where the locality is largely foreign. The material thus obtained will be classified and made available for all workers. As far as possible the city work must be based on a knowledge of conditions, obtained through well-directed investigation. Fortunately several studies have already been made which are very suggestive.

A glance into the future shows an increasing demand for well-organized courses of instruction to suit the needs of a great variety of groups. Much more attention must be given to the content of these courses and the methods to be employed. Correspondence courses and extension schools are certainly as much needed in the city as in the rural community.

The campaign method is best adapted to this present emergency in order to reach the largest number of people in the quickest way. This method arouses interest and creates a right attitude toward the food situation, but it must be supplemented by study classes and study clubs in order that enthusiasm may express itself in intelligent action.

Considerable time has been spent by one of the assistant State leaders in the preparation of outlines and other material for the use of the city agents.

The variety and usefulness of the work has been indicated by what has been done since October 22 by one of the assistant State leaders. She has gathered bulletins, recipes and posters for food rallies in Lowell, Taunton and Haverhill; has prepared menus for conservation suppers; has given 26 lectures; has arranged a study class in conservation, a series of food demonstrations in the Jewish synagogue, a study class in emergency food work in St. Paul's Cathedral, Boston; has co-operated with the Women's Municipal League in their work in food conservation in stores by giving 6 lectures and demonstrations to 1,800 employees.

In all this activity it is very important that there should be a system of follow-up work with reports, varying according to the previous experience and preparation of the group. Time may well be given for home visits and for round-table discussions with exhibits arranged for small groups. In some groups each member may be responsible for carrying the message received to ten other women.

The future development will lead to well-organized groups in all sections of the city; carefully arranged subject-matter adapted to the needs of the special groups; and a large force of well-trained workers who shall help to solve for many people the problem of better living.

STATISTICS.

State Leader.

Number of visits to the city committees,	30
Number of meetings of large committees attended,	11
Number of lectures given,	19
Total number of people in attendance,	2,115
Number of conferences,	57[1]
Number of candidates for positions interviewed,	50

Assistant State Leader.

Number of visits to city leaders,	3
Number of demonstration lectures,	10
Number of lectures,	16
Total number of people in attendance,	3,822
Number of conferences with people coming to office,	24
Number of study classes being conducted,	2

City Leaders.

Boston: —	
Number of conferences with district committees,	12
Number of miscellaneous conferences,	35
Number of demonstrations and lectures,	30
Number of educational exhibits,	6
Haverhill: —	
Number of conferences for organization purposes,	6
Number of study classes being held weekly,	3
Number of public lectures and demonstrations,	30
Number of educational exhibits held,	6
Lowell: —	
Number of conferences with district leaders and for organization purposes,	7
Number of lectures and demonstrations,	9
Number of window displays,	1
Number of church conservation suppers,	2

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[1] This number does not include the interviews with candidates.

Taunton: —	
Conferences for organization,	5
Number of miscellaneous conferences,	6[1]
Establishment of a thrift center for demonstrations and lectures,	1
Brockton: —	
Number of conferences (definite meetings),	7
Number of lectures,	3
Number of classes held or being held,	7
Holyoke: —	
Number of conferences for organization,	8
Number of lectures,	2
Springfield: —	
Number of conferences,	46
Number of lectures and demonstrations,	26
Number of training classes,	1
Number of window exhibits,	4
Number of exhibits (Eastern States Exposition),	1
Northampton:[2] —	
Number of conferences for organization,	11
Number of lecture demonstrations,	3
Mrs. Herron: —	
Number of conferences,	15
Number of lectures,	17
Number of demonstrations,	2

County Agricultural Agent Work.

The county agent work now embraces every county in Massachusetts except Suffolk. There are 36 men employed at the present time, 19 of whom are co-operatively employed, 17 by the counties alone, an increase which was made necessary by the special emergency project as part of the program of the committee on food production. It is probable that with the exception of 6, all of these men may be regarded as permanent employees of the farm bureaus.

As to the regular farm bureau projects, special emphasis has been laid on the organization of the dairy industry, since this matter seemed one of greatest importance during the early part of the year. As far as the county agents were concerned the complete organization of the milk producers in the New England Milk Producers' Association relieved the situation very considerably.

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[1] This number represents simply the number of different organizations with which conferences are constantly being held.

[2] Work has been discontinued at Northampton.

A special survey of the milk producers of the State was made, and the county agents assisted materially in gathering facts for this project. The other usual projects in farm crops, boys' and girls' club work, and other activities were well started. The development of the work in home economics, which has required a great deal of time on the part of the county agricultural agents, has strengthened the farm bureaus as much, probably, as any project that has been taken up.

Early in March came the call for assistance in a nation-wide campaign for increased food production. The regular projects of the farm bureaus were suspended, and a large part of the time of the county men and women was spent on this work. The organizations of town committees on public safety and food production necessitated some exacting work on the part of the county agents and others so to arrange matters that this might be accomplished satisfactorily and without friction. The plans have been made for four county agents at large working in specified districts. These agents work in close co-operation with the regular county agents on marketing problems. Each man is to be in one of the following districts: —

District 1, Essex and Middlesex Counties.
District 2, Barnstable, Plymouth, Bristol and Norfolk Counties.
District 3, Worcester County.
District 4, Berkshire, Franklin, Hampden and Hampshire Counties.

Agents are now at work in all districts except District 2.

JUNIOR EXTENSION WORK.

During the early part of this year the junior extension work was continued in the usual way. Time was devoted to the formation of clubs along the lines of corn, potatoes, home gardening, canning, poultry, pig, home economics and market gardening. After the appointment of the Public Safety Committee in the early spring work was begun to interest the young people in food production and conservation through the agency of public meetings, lectures at schools and school organizations. Four workers were employed permanently, and at certain times, when increased pressure demanded a greater force, the number was increased to 8. The Massachusetts Public Safety Committee financed a large part of the additional work. After the passage of the emergency agricultural bill an assistant State leader was appointed. This made a permanent staff at the college of five members, consisting of a State leader, an assistant State leader, a pig club agent, a poultry club agent, and a home economics and canning agent.

Since Dec. 1, 1916, approximately 58,664 people have attended demonstrations and meetings held in connection with the work of our five workers.

Practically every county in the State had a boys' and girls' club specialist who devoted full time to organization and instruction. Emphasis during the past year has been specially placed upon organization. Effort has been made to work through the county farm bureaus as far as possible. In a majority of the counties club workers were employed for the first time. These county workers endeavored to find local leaders in the various communities who would take charge of the work in the smaller groups. In Hampden County 18 of the 20 towns appropriated money for local leadership as a result of the effort of the county club leader. In Franklin and Hampshire counties several towns at their annual meeting appropriated money for this work. In many cities the school departments appropriated money for club work. In most cases this money was used to pay the salary of a supervisor or a supervisor and assistants. Our records show that there have been at least 230 paid local leaders and 240 volunteer local leaders who have conducted work during the past year.

Where county organizations have failed to take up the work the department acted upon request directly with the community. In many instances projects were carried on with individuals where neither county nor community interest had yet been aroused. To-day work is being conducted by the college, usually through the county agent, in every one of the 14 counties of the State.

A number of organizations have contributed to the club work, usually in the form of offering prizes to boys and girls who have successfully done a certain required amount of work. The State Board of Agriculture appropriated $2,000 to be spent to further such plans. A citizen gives this year $150 to be applied as a scholarship. The Brockton Fair Association increased the amount given for fostering this activity from $200 to $500. The Hampshire County Fair Association erected a brick building costing $5,000 to be used as an exhibit hall for club work. The Barnstable County Fair Association held a club exhibit for the first time, and voted money for premiums. More emphasis has been given at the various fairs of the State to the boys' and girls' club work, and much interest is shown by the grown people as well as by the juniors.

At the suggestion of the Norfolk County agricultural agent a new form of project is being tried out under the direction of the assistant State leader. Junior extension schools are being developed in which it is hoped that a larger amount of thorough instruction will be given than has been possible in the past.

Boys and girls in many instances did canning in units. As many as 3,500 jars were canned by some of these groups, and several records were made by individual boys and girls who canned from 500 to 800 jars of fruits, vegetables and greens. The figures at hand show great increase in interest, not only on the part of the children, but also on the part of the adults. The following table represents the results of this work in a concise form: —

PROJECT.	Total Enrollment.	Date Enrollment will close.	Date for Reports to be in.	Size of Plat; Number of Birds; Number of Animals.
Corn,	160	July 1	Nov. 1	½ or 1 acre.
Potato,	492	July 1	Nov. 1	⅛, ¼, ½ or 1 acre.
Home garden,	87,948	-	-	1 square rod.
Canning,	3,067	July 1	Nov. 1	24 quarts.
Poultry,	652	June 1	Nov. 1	10–100.
Pig,	2,200	June 1	Oct. 1	1 or more.
Home economics,	1,991	Feb. 1	May 1	60 hours' work.
Market garden,	992	July 1	Nov. 1	1/20 acre.
Total,	97,452	-	-	- -

Printing and Publicity.

The high prices which now hold for all kinds of printing has made necessary the publishing of only such material as was urgently needed. On the other hand, emergency work has made necessary the compiling of circulars, bulletins and other material which otherwise would not have been published. On all orders of any size, competitive bids were obtained from certain printers whose output was known to be satisfactory, and the order placed with the lowest bidder. The system of classifying manuscript into news letters, circulars, leaflets and bulletins has been continued, and all matter offered for publication has had the approval of the heads of the departments concerned and the committee on publications before it has been sent to the printer. During the year this department had printed 335,000 miscellaneous publications, such as announcements, certificates, cards, letterheads, charts, etc. There were also printed 866,000 extension circulars, 24,000 extension bulletins, 3,000 library leaflets, 91 news letters and 15 special news letters.

Special attention has been given to the news letters to the end that they might carry important and interesting information, in a form which both the newspapers and their readers would want and at the same time represent the best opinion and teaching of the college. In order to meet the demand of the press, these letters have been made specific for papers in certain sections of the State where such a result was at all possible. As a result, the majority of the papers throughout the State, and particularly the larger ones, regard with consideration the college news letters, and the college is, therefore, enjoying strong co-operation on the part of the State press.

Library Extension Work.

During the past year there has been a greater demand for books and bulletins than in any previous year; the general increase in extension activities being largely responsible for this demand. As these requests have been met, the library has had a very active year. During the year, 56 libraries throughout the State were loaned a total of 820 books and 170 bulletins.

COMMUNITY ORGANIZATION.

Special work with various farm bureaus may be reported, as follows:

Supervision.

(*a*) The supervision of organization has been continued or started in 36 towns. This work has involved from one to four visits each, together with sufficient correspondence to insure satisfactory progress.

(*b*) Eleven towns are now completely or partially organized.

(*c*) The Barnstable County Council of county organizations has been given supervision. A new council has been organized in Essex County. Preliminary work has been done for councils in Norfolk, Plymouth, Berkshire and Franklin counties.

(*d*) County surveys have been made in Barnstable, Plymouth and Essex counties. These projects involved an organization survey, showing the organizations of each town and the work they are doing; a preliminary agricultural survey, showing the principal needs of each town; and an outlining of the next step to be taken in the developing of each town.

Work has been continued with the Massachusetts Federation for Rural Progress, which is made up of 28 State organizations, boards and institutions which have made this federation a clearing-house for the exchange of plans and projects for the better working out of inter-organization relationships. At the midwinter meeting in March the federation appointed a committee on food production and conservation which was later taken over by the Committee on Public Safety as the official State organization for this work. Work has continued with the Massachusetts Development Committee along three lines: (*a*) the outlining of the rural problem in Massachusetts; (*b*) a study of the work of each State-supported board, department or institution; (*c*) an effort to form a plan for the correlation of State boards, departments and institutions.

Annual Conference.

The annual conference on rural organization considered the question of food supply and conservation. The conference was attended by 200 people.

Bulletins.

A large amount of time has been spent on the preparation of bulletins. It is hoped that the material will be ready for publication early in 1918.

CORRESPONDENCE COURSES.

The work of conducting the correspondence courses has been continued much as in past years. Some of the courses have been revised, while others should be revised in the immediate future. The various members of the faculty seem to be too busy to undertake this work in the way in which it should be done. If satisfactory correspondence work is to be done in the future, more attention must be given to writing up the lectures for the courses.

A special effort is being made this year to bring individual students into study groups. Members of the college faculty meet these groups for the purpose of delivering lectures and answering questions concerning the problems which the members of the class have noted. The college library, through the co-operation of local libraries, has loaned a number of textbooks and reference books to study groups. We believe that there is a large place in the State for a well-developed correspondence course. We hope to devote enough time to this project during the coming year to build up a first-class correspondence course.

During the fiscal year ending Nov. 30, 1917, enrollment in correspondence courses was as follows: —

Soils and soil improvement,	87
Manures and fertilizers,	40
Field crops,	20
Farm dairying,	22
Fruit growing,	61
Market gardening,	69
Floriculture,	2
Farm accounts,	26
Entomology,	9
Beekeeping,	14
Forestry,	9

Shade tree management,	73
Poultry husbandry,	218
Home economics,	83
Total,	733

Educational exhibits were made at the following seven fairs of the State: Barnstable, Worcester, Lincoln Park, Greenfield, Fitchburg, Lowell and Northampton.

This work is carried on in co-operation with the various fair associations, each association bearing a part of the cost of the exhibit. War emergency food conservation and production were emphasized this year in all the exhibits.

Itinerant Schools and Farmers' Week.

The eighth annual farmers' week was held March 26 to 30, inclusive. There were four departmental educational exhibits; 140 lectures and demonstrations were given, which 800 persons attended.

Polish Farmers' Day, held on March 22, included a program of 12 lectures and demonstrations which were given before 300 people.

There were 9 extension schools conducted during the year, 1 being devoted entirely to home economics and the remaining 8 to both agriculture and home economics. The attendance at the agricultural extension schools was 378, while that at the home economics schools was 500. Instruction was given as follows: home economics in 9 schools, animal husbandry in 8, fruit growing in 8, technology in 8, poultry husbandry in 7, farm management in 3 and market gardening in 1. The average attendance at the agricultural schools was 24.6, and at the home economic schools, 27.7.

There were also three four-day training schools held at the college, July 10 to 13, 17 to 20 and 24 to 27, to which 83 persons came representing 45 towns in the State. Five instructors conducted these meetings. Food conservation schools of one day's and two days' length were held May 24 to August 22 in 85 communities throughout the State. Five of these covered a period of two days, while the remainder were one-day sessions.

Twelve instructors assisted at these schools and gave instruction to 10,213 persons.

Aside from these well-recognized projects, 49 members of the college staff, experiment station and extension service delivered 897 lectures before various organizations and communities, at which there was an estimated attendance of 58,305.

Mr. Shaper, before general meetings on food conservation and farm bureau work on the islands of Nantucket and Martha's Vineyard, gave 20 lectures before 1,725 persons.

Animal Husbandry.

As in past years, the work in animal husbandry has been carried on by the entire staff of the department. This year, in addition to the regular staff, a graduate student and a senior student majoring in this subject devoted considerable time to extension activities. The larger part of the extension project was done by the extension specialist in animal husbandry, who devoted his entire time to this work. In October a sheep specialist was assigned to our extension service for work on sheep production. An effort will be made to increase sheep production in those portions of the State where it seems advisable.

Extension Schools.

Lectures were given at 8 different schools. In 6 schools a full week's course in animal husbandry was offered. A satisfactory feature of the work last year was the farm visits made in connection with the schools. This seemed to be a very valuable part of the instruction, because while many herd owners are reluctant to take advice from their neighbors, they are often glad to consult with a specialist from outside. This work can only be effectively done when visits are made. Not as much evidence of the lasting effects of these schools is available as would be desired. Even when schools have been held in favorable animal husbandry sections, the number of pure-bred stock does not seem to have been materially increased. In one or two sections, however, there is decided evidence of improvement.

Co-operative Bull Associations.

The work with co-operative bull associations, organized at Winchendon in co-operation with the Dairy Division of the United States Department of Agriculture, has progressed satisfactorily. It has been decided not to increase the size of the association because of the lack of finances for carrying on such investigation. Possibly an increase of two more breeding blocks to this association will be possible in the spring, when it is hoped that this work can be pushed.

Dairy Improvement Associations.

There are now four dairy record associations, which is the same number we had in the State last year. Much more difficulty has been experienced this year than usual in keeping these associations in operation. This is due to the greater difficulty in getting satisfactory testers. There is a strong demand for the type of man that makes a satisfactory tester for advanced registry work, and for superintendents and herdsmen, on pure-bred farms. One association has been forced to discontinue the testing, and another is only doing intermittent testing until satisfactory men can be obtained.

Dairy Record Work.

Daily milk record sheets have been supplied to 60 herd owners who have not previously kept records. This is in addition to those supplied by county agricultural agents, 6 of whom have obtained records from this office during the year. Record sheets have been furnished to 4 agricultural school men who keep home herd records as part of their school work. It is hoped that permanent record keeping in each of these herds will develop from this school project scheme.

Fair Demonstration Work.

The value of silage as a feed for dairy cattle and the relative value of different varieties of corn for ensilage were emphasized in our college exhibit at the fairs this year. The relative weights of the different factors affecting the cost of milk on the farm and the cost of milk production at varying amounts produced were shown on charts based on figures obtained from the survey made last spring on the cost of milk production. Sample rations that would be suitable for the feeding of young stock and for feeding with legume hay and with ordinary grass hay were shown. In co-operation with the agronomy department exhibits were made showing the proper method of selecting, storing and testing seed corn, the fumigation of beans, and the use of lime in the growing of legumes.

Live Stock Judging.

The extension specialist and other members of the animal husbandry department judged classes of live stock at 11 different fairs. It may be that, in the future, work with smaller fairs will be taken up, as there seems to be a demand for this work.

Boys' Stock Judging Contests.

Fourteen different contests were given supervision by some one from the animal husbandry department. There were 200 contestants. At the Eastern States Exposition, where the judging contest was limited to a team of three from each State, the Massachusetts team finished first. This team was selected from among those who took part in the local contests.

One of the boys who took part in the contests a year ago is now a member of the sophomore class at this college. Another has come in with this year's entering class, and at least four others have signified their intention of taking up agricultural college work when they complete the course they are now taking.

Lectures.

Under this project comes a large part of the extension work done by the members of the animal husbandry department other than the specialist. A number of these lectures were given at the request of the different county agents.

Agricultural Surveys.

In connection with the emergency work considerable time was spent with two agricultural surveys. One of these surveys was upon the cost of milk production.

Sheep Husbandry.

Work in sheep husbandry is being carried on in this State and the State of Rhode Island in co-operation with the United States Department of Agriculture. The work consists in aiding farmers in building up the industry by helping them to secure breeding stock, aiding in the various problems of management, and in trying to secure a fair and adequate dog law.

Statistical Summary.

Extension schools,	8
Lectures,	64
Attendance,	1,561
Agricultural fairs: —	
Exhibit,	8
Judging,	11
Junior stock judging contests,	14
Contestants,	200
Single lectures,	24
Attendance,	950
Agricultural surveys,	2
Farm census (days),	10
Cost of milk production (days),	25
Material published: —	
Extension circulars,	4
Miscellaneous meetings and conferences,	32

BEEKEEPING.

A very large amount of miscellaneous work is reported by our specialist in beekeeping, the principal lines of activity being the exhibits on the fair circuit and the five beekeepers' field days and conventions held during the summer. In addition, a four-day beekeepers' school was held in Dalton with an attendance of 50 persons. The usual work with the correspondence courses and farmers' week has been continued.

Co-operative Organization and Marketing.

The work of this department was conducted by two persons.

Production Surveys.

Under the supervision of the department of agricultural economics a census of production was conducted in the spring of this year. This census covered the five western counties of the State, in each of which the work was carried on with the co-operation of the county farm bureau. The actual work of collecting this information was done largely by students from the college.

This survey covered total farm areas, — acres under cultivation, in pasture and in woodlots; acreage devoted to various staple crops in both 1916 and 1917; live stock for both years; poultry and dairy products, and quantities of all products stored and sold. Information was also secured with reference to farm buildings, storage and individual needs for credit or farm labor.

The data thus obtained were tabulated in the department, some half dozen members of the faculty not otherwise engaged in emergency work making the tabulations. The returns were carefully summarized and have been filed with each county farm bureau for reference.

Milk Distribution Survey.

Acting in co-operation with the Attorney-General of the Commonwealth, the department has made a study of the cost of distribution of milk by small dealers in Boston and vicinity. Figures were obtained from some 20 dealers, and extensive statistical tables prepared showing the volume of business of each dealer, with his total cost and per quart costs of operation. This study was made for the purpose of determining a fair price of milk to the consumer.

Farmers' Co-operative Organizations.

The usual work on farmers' co-operative organizations has been carried on successfully. Besides the organizations listed, many more have been helped in preliminary work and after organization, although no credit is taken; notably among these are two farm bureaus, two co-operative milk distributing associations, a large number of milk producers' associations, and farm loan associations.

Organizations formed.

	Incorporated.	Not incorporated.
Milk,	-	2
Farm bureaus,	1	-
Co-operative exchanges,	4	1
Farm loan,	2	-
Tobacco,	-	2
	7	5

Advice has been given all co-operative exchanges as to legal rights and duties. Aid has been given to many in making out certificate of condition reports, franchise tax reports and income reports to the Federal internal revenue collector. Better business methods have been taught and information spread as to where satisfactory purchases might be made.

Miscellaneous.

During the first part of the fiscal year the regular work of the department was carried on, but with the declaration of war plans were dropped, and new work was immediately started. A food production survey was started in the five western counties, and assistance was given in organizing and gathering material. Help was received from the college student body, public safety committees, farm bureaus, Y. M. C. A., public schools and individuals, especially clergymen.

With the organization of the National Farm Land Bank demands were made for lectures and organization of such associations. These demands were filled, lectures being given and two local associations formed. The one in Pittsfield was probably the first association organized in this district. The total requests asked for at the meetings of organization was $104,000.

An attempt was made to have the Legislature pass a new law governing the organization of co-operative associations. The attempt was a failure, and the bill was referred to the next

General Court. The extension specialist has also appeared for and against other bills in the interest of marketing farm products.

A long-felt want has been supplied in the establishment of a market exchange clearing through the extension specialist from the county agents. This exchange will be gradually developed, and will aid greatly in letting county agents know where high-grade animals, seed, etc., may be bought and sold.

The call for lectures has come in, as in the past, on a wide variety of subjects. These lectures have been given before Co-operative Exchanges, Granges, Chambers of Commerce, Boards of Trade, Extension Courses, Milk Associations, public schools and general meetings. The total number of lectures given was 84, with an attendance of 4,110.

A number of conferences have been attended bearing on the various lines on which the head of the department and the extension specialist are working. The total number is 64.

On the 1st of September the extension specialist was appointed assistant county agent leader in charge of a new marketing project. Three assistant county agents at large have been appointed to date to work on this project. Much time has been spent in laying plans, acquainting these men with the conditions, and assisting and advising concerning the way the work should be undertaken.

Striking results have been shown in improved grading of all kinds of fruits and farm products offered for sale, with satisfactory financial results. While the process is slow with individuals, the co-operative exchanges have taken up the matter readily.

The extension specialist has had under consideration for some time the federation of the exchanges. There has been some demand for a State organization. However, it is his belief that the time for such a step is hardly here.

At present these exchanges are on a satisfactory basis, and care must be taken not to push too many into existence. Local conditions must be studied in all cases and the proper spirit among the members shown. It is hoped that the growth will be gradual and not pushed backward by parties not realizing the difficulties encountered by co-operative organizations.

Dairying.

The most important work done by the dairy department the past year was the holding of two shows and four quarterly scorings for dairy products.

The show held in conjunction with the annual winter meeting of the State Board of Agriculture in Springfield, Jan. 9 to 12, 1917, had 263 samples of milk and cream, 17 samples of butter, and 3 samples of cottage cheese. This was the first time there has been a class for cottage cheese, and it is hoped that the number of samples in this class will be much larger in the future, especially so since the United States Department of Agriculture has been doing so much in advising the manufacture of cottage cheese from surplus skim milk.

The attendance at this show would doubtless have been much larger had the weather been more favorable. The two days on which samples were to be taken by the milk inspectors were the worst days of the year. The inspectors are very enthusiastic over this work, and expect to have more samples in the next show than ever before. They have also been instrumental in securing cups as prizes and in influencing many producers and dealers to exhibit in the various classes.

The second show, or first quarterly scoring, was held during farmers' week. This show had 64 samples of milk and cream and 10 samples of butter.

The second quarterly scoring was held at Amherst in July. Owing to the fact that this was the first scoring at which no prizes were offered, and that there was a shortage of milk and of farm labor at this time, the number of samples was small, there being 16 samples of milk and cream and 2 of butter. However, for a first undertaking of the kind this number was fairly satisfactory.

The third quarterly scoring was held in connection with the dairy products show of the Eastern States Exposition, at Springfield, in October. A member of the Department was superintendent of this show and had entire charge of it. There were 30 samples of milk and cream and 24 samples of butter exhibited.

The dairy department also had charge of the milk samples for a milk show at the Fitchburg Fair, under the auspices of the

Fitchburg milk inspector. A representative from this department was at the fair for two days.

In December a member of this department had charge of a local milk show at Taunton. At this show there were 43 samples on exhibition.

Since it is recognized as the best means of improving a community's milk supply, there is no doubt that many local milk shows could be held in co-operation with the milk inspectors if we had a man for this class of work.

The Massachusetts Dairymen's Association, the Massachusetts State Board of Agriculture, the Massachusetts Milk Inspectors, the United States Department of Agriculture, and the Eastern States Exposition have co-operated with us in these shows. The Dairymen's Association, the State Board of Agriculture and the Eastern States Exposition have co-operated with financial aid. The milk inspectors have assisted by awakening interest among the producers and dealers and getting them to submit samples. The United States Department of Agriculture has furnished a judge for milk and cream for two of the three scorings. In connection with the shows the experiment station and microbiology department have co-operated by doing the analytical and bacteriological work.

Another undertaking carried out by this department was the collecting and tabulating of data on the cost of milk production. The head of the department was chairman of this committee, and two members of the department spent ten days each in collecting and several days in tabulating the data.

Relative to the milk shows and dairy meetings, we have sent out about 12,000 announcements and circular letters, and have answered about 1,600 letters in answer to inquiries.

Under a co-operative arrangement with the United States Department of Agriculture, demonstrations and lectures on the home manufacture of soft cheese were given in various parts of the State.

There have also been a considerable number of requests for help in getting out plans and equipping co-operative milk plants, and it is believed that this feature of the work will increase in the future. Many of the milk inspectors desire our assistance in conducting local milk shows, and there is interest and desire to make the quarterly scorings of milk, cream and butter much larger. With the amount of teaching which the department is doing, it is felt that a man should be secured to devote all of his time to extension projects, a large part of which would be in connection with the milk shows.

Farm Management.

The success of our work in farm management has well proved its worth. Our specialist has labored very successfully both with the farmers and with the county agricultural agents. His instruction has been of a very personal nature, and has resulted in a great deal of good both to the farmers served and to the college. Mr. Bronson has left us to go into the United States Navy, and we feel that he is a very great loss. We trust that it will be possible to employ a good man to take his place temporarily. In addition we need an extra man to work in this field. In spite of the fact that Mr. Bronson has been very successful in securing the co-operation and help of the county agents for a large part of the work, it has been impossible to carry on the undertaking as extensively as would be desirable.

Plant Diseases.

Our extension specialist who is assigned to us by the Department of Agriculture began work November 2, though his appointment was not effective until November 13. His principal assignment has been on the diagnosis of plant diseases, correspondence regarding the same, together with the collection of material to be used in lectures and in future field instruction.

This work should be developed during the coming season to include assistance for the vegetable gardeners and for the growers of potatoes and beans.

Pomology.

As in previous years a considerable portion of our extension work has been done by all members of the department of pomology. Mr. Kilham devoted his entire time to extension work in pomology until April 12, when he took up his duties at the State House with the Committee on Food Production and Conservation of the Massachusetts Committee on Public Safety. On June 16 he returned to the college, devoting a small part of his time to pomology and most of his time to food conservation schools. On August 24 he became acting director of the Extension Service.

On May 15 Mr. Ralph A. Van Meter became a temporary worker in the food conservation campaign. On October 1 he took up temporary work as the extension specialist of the department.

Professor Chenoweth served as chairman of the campus committee on food conservation and devoted a large part of his time to this enterprise, both on the campus and throughout the State.

The regular extension program of the department was greatly handicapped because it seemed best for the extension specialist to devote a large part of his time to emergency work. Both Professor Sears and Professor Chenoweth, however, devoted an unusual amount of time to the extension projects, and so materially aided the extension activities.

Demonstration Orchards.

As time goes on it becomes more and more evident that the demonstration orchard is one of the finest types of extension work that we could carry on in the State. These permanent orchards which are scattered over the State give a center for information for the surrounding orchardists, and are a constant example for the use of both the department of pomology and the county farm bureaus. The following is a list of our demonstration orchards: —

Planted 1910: —
E. B. Clapp, Westhampton, Hampshire County.
Frank T. Haynes, Sturbridge, Worcester County.
A. L. Fish, Colrain, Franklin County.
George C. Thurlow, West Newbury, Essex County.
Planted 1911: —
L. B. Dickinson, Granville, Hampden County.
C. M. Ottman, North Adams, Berkshire County.
C. W. Wilson, West Medway, Norfolk County.
Planted 1912: —
H. A. Dunbar, Richmond, Berkshire County.

Planted 1913: —

C. W. English, East Brookfield, Worcester County.

A. S. Ashley and W. S. Rounsevell, South Hanson, Plymouth County.

Gustaf Anderson, Pepperell, Middlesex County.

Walter Sampson, Lakeville, Plymouth County.

Planted 1915: —

Henry L. Green, Paxton, Worcester County.

Planted 1917: —

Henry B. Wells, Buckland, Franklin County.

The orchard of Mr. A. W. Bagnell, at Enfield, Mass., was sold, and as it had not been well cared for for several years it was decided to cancel our contract. The orchard of Mr. Joseph B. Cobb, at Chicopee Falls, which was planted in 1914, was neglected from the start. We found it necessary to cancel our contract with Mr. Cobb and collect from him a large part of the expense incurred in the establishment of his orchard. Since our last report Mr. Frank H. Taylor of South Hanson, whose orchard was planted in 1913, sold his orchard to Messrs. A. S. Ashley and W. S. Rounsevell. We are very sorry to lose Mr. Taylor as a co-operator, as his orchard has always been a splendid one for our purposes. We have renewed the contract with the present owners, and believe that the orchard will make even a better record in the future.

Most of the orchards show a very good growth and are in splendid condition. Lack of labor during the past season has caused some neglect which we hope will not be continued in the future. The orchards at Westhampton, Sturbridge, Colrain, West Newbury, Granville, North Adams, West Medway, Richmond and Lakeville are in very fine condition. The orchard at Lakeville has peach trees as fillers for the apple trees. This orchard, which was only planted in 1914, harvested a large crop of peaches this year. The orchards at South Hanson, Pepperell and Paxton are in medium condition, while the orchard at East Brookfield is in very poor condition. The poor condition in some of these orchards is largely due to neglect on the part of the owners to carry out the instructions that have been given. In some cases it was impossible, because of financial and labor conditions, to carry out the instructions.

Because of the importance of our demonstration orchards in furthering extension work in pomology, it is to be hoped that nothing will prevent the extension specialist from devoting full time to this work in the future. The orchards are now at just the stage when they need most careful supervision. One man could well devote his entire time to this project alone.

Extension Schools.

Pomology instruction was given in a number of the extension schools during the past winter. In most of these schools only half the week was devoted to the subject of pomology. It has been impossible to develop satisfactory follow-up work for pomology because of the fact that the extension specialist would not have time to devote to such follow-up work. Some follow-up work has been done, however, by the county agricultural agents, and this has proved quite satisfactory.

Pruning Campaign.

Pruning during the past year was carried on largely in connection with the pruning of our demonstration orchards. The specialist usually spent a part of a day or a whole day in each demonstration orchard, and then spent a day or two additional in giving demonstrations in other orchards in the county with the county agents.

Miscellaneous.

Something has been done on the other undertakings indicated in the pomology project, but pressure of more important work prevented their being carried out very fully. The following statistical summary is not complete in the case of any of the men, except Mr. Kilham and Mr. Van Meter: —

	Miscellaneous Fruit.		Extension Schools.		Conservation Schools.		Farmers' Week.		Demonstration Orchards.		Massachusetts Committee on Public Safety.		Food Conservation.		Total.	
Mr. Kilham: —																
Lectures,	11		40		7		2		-		3		-		-	
Attendance,		537		949		320		80		-		246		-		-
Conferences,	40		-		-		5		-		-[1]		-		-	
Attendance,		98		-		-		26		-		-		-		-
Visits,	19		8		-		-		20		3		-		-	
Attendance,		80		-		-		-		-		-		-		-
Demonstrations: —																
Evaporating fruit,	-		-		7		-		-		-		-		-	
Attendance,		-		-		337		-		-		-		-		-
Pruning,	4		2		-		-		7		-		-		-	
Attendance,		98		40		-		-		108		-		-		-
Spraying,	-		-		-		-		1		-		-		-	
Attendance,		-		-		-		-		35		-		-		-
Totals,	74	813	50	989	14	657	7	106	28	143	6	246	-	-	179	2,954

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[1] Many conferences every day.

	Miscellaneous Fruit.		Extension Schools.		Conservation Schools.		Farmers' Week.		Demonstration Orchards.		Massachusetts Committee on Public Safety.		Food Conservation.		Total.	
Mr. Van Meter: —																
Lectures,	1		-		41		-		-		-		-		-	
Attendance,		21		-		2,280		-		-		-		-		-
Demonstrations,	-		-		20		-		-		-		-		-	
Attendance,		-		-		2,266		-		-		-		-		-
Totals,	1	21	-	-	61	4,546	-	-	-	-	-	-	-	-	62	4,567
Dr. Shaw: —																
Lectures,	1		-		-		-		-		-		-		1	
Attendance,		20		-		-		-		-		-		-		20
Professor Sears: —																
Lectures,	7		-		-		-		-		-		-		7	
Attendance,		970		-		-		-		-		-		-		970
Professor Chenoweth: —																
Lectures,	3		5		-		-		-		-		4		-	
Attendance,		85		150		-		-		-		-		600		-
Conferences,	15		-		-		-		-		-		-		-	
Attendance,		50		-		-		-		-		-		-		-
Visits,	2		-		-		-		-		-		-		-	
Attendance,		6		-		-		-		-		-		-		-

Demonstrations,	-		-		-		-		-		-		2		-	
Attendance,		-		-		-		-		-		-		150		-
Totals,	20	141	5	150	-	-	-	-	-	-	-	-	6	750	31	1,041
Grand totals,	103	1,965	55	1,139	75	5,203	7	106	28	143	6	246	6	750	280	9,552

POULTRY HUSBANDRY.

In reviewing the extension poultry work for the year it may be noted that the general interest in extension work throughout the State has greatly increased, so much so that the available force is inadequate to meet the demands made upon it.

Extension Schools.

In the nine schools which were held, the program consisted of a full week's work, either alone or in conjunction with some other branch of agriculture. Lectures and demonstrations were given, and as far as possible these were planned to meet the needs of the particular community in which the school was located.

Fall Fairs.

A poultry exhibit was incorporated into a general extension exhibit for the fall fairs, and was taken to eight of these fairs in various parts of the State. These exhibits were designed to emphasize particularly the methods for increasing production.

Poultry Convention.

The fourth annual poultry convention was attended by more than 500 men and women, all of whom were vitally interested in poultry husbandry. Lectures were given by members of the college staff and by lecturers from outside of the State, so that seventeen lectures and demonstrations of a very practical nature were presented. It is felt that these conventions are of inestimable value, since they give the poultryman an opportunity to see what is being done by the college department, and enable the men and women of the State to get away from their work for a short period and see what is being done by others in the same line of activity. An exhibit was, as usual, an important feature of the meeting, and was arranged so that visiting poultrymen could have their questions answered in a very definite way.

Farm Visits.

A great many poultry farms have been visited throughout the year. These visits were arranged, where possible, in communities when lectures and demonstrations were being given so that the two might supplement each other, thereby simplifying the work and making possible many more visits than would otherwise have been made. During the past year at least three different poultrymen have reported that a definite practice, followed on the suggestion of an extension worker, saved for them several hundred dollars.

Field Meets.

Several field meets have been held under arrangements made by farm bureaus. Small groups of from ten to twelve poultrymen met at a specified poultry plant that was selected because of some particular feature. The visitors were shown the details of the plant, and criticisms were made by the specialist on the particular methods of operation employed. Such work is of inestimable value, in that it puts before the poultrymen instruction in a more definite and satisfactory manner than when the same facts are presented through the ordinary lectures or demonstrations.

Fairs judged.

Several fairs were judged during the winter, principally along utility lines. The utility departments of the winter shows were seriously handicapped by a lack of trained judges, and the extension force has rendered a distinct service by furnishing several members of the faculty for this work. This work was of value not only by reason of the actual judging, but chiefly because the judge was usually able to give a demonstration of judging to prove the relative merits of the birds.

Exhibits.

During the winter show season the department furnished an educational exhibit at eight of the larger poultry shows. These were accompanied by the poultry specialist, who gave lectures and demonstrations at stated times. Much value was derived from these exhibits, more particularly because such exhibits impressed upon people the fact that the college was ready to help them with their problems.

Out-of-State Meetings.

Nine meetings have been attended during the year outside the State. The value of this attendance lay in the conferences which our own workers had with those of other States, and the resulting exchange of ideas.

Special Campaign.

The rapid increase in the cost of feed, together with the general market conditions, created a feeling of uneasiness on the part of the producers. In order to meet this situation a project was drawn up by the Extension Service which was presented to the Massachusetts Committee on Public Safety. This committee appropriated sufficient funds to defray the expenses of several men within the State. The department, therefore, was able to place ten men in the field who emphasized the importance of retaining producing stock. As a result, a general feeling of confidence was re-established, and the poultrymen, as a whole, planned to produce more than in former years. These results were accomplished by placing a well-trained man in a county, who visited individual poultrymen and attended night meetings which were arranged by the farm bureaus. In this way approximately 6,000 people were reached by lectures and 480 farms were visited.

Correspondence Course.

Instruction through correspondence has proved to be a popular and valuable form of Extension Service. Study groups have been formed where possible, and have been met by members of the department whenever arrangements for such a meeting could be made. The importance of this work has demonstrated the advisability of giving even greater attention to it in the future.

Miscellaneous Extension Work.

The work which we call "home work" is considered of great value. Several hundred visitors from all parts of the State have inspected our poultry plant, bringing their personal problems for our consideration and taking away renewed enthusiasm and ideas which materially help them in their own efforts. Correspondence has also been an important factor in bringing the poultrymen into closer touch with the college, and the increase which has taken place in the number of letters received and sent seems to indicate that this relation is yearly growing closer.

Rural Civic Planning.

The development and progress of the work in rural civic planning during the past twelve months has been most gratifying despite the unsettled conditions through which the country is now passing. Requests for assistance are being received in increasing numbers. The smaller communities seem to feel the need of activity of a constructive nature at home to keep up their interest in town affairs. In fact, throughout the United States, now that the first excitement of the war is over, the towns and cities are turning with renewed vigor to the renovation, extension and development of their town plans.

The conditions under which the work has been undertaken by this department have been those which proved to be satisfactory and successful, namely: —

1. The special desire of the college to assist the small rural communities which have been given the preference.
2. The confining of the projects to strictly public enterprises.
3. The payment by the communities or organizations served of the expenses of travel and drafting of plans.
4. The turning over to professional men of work which can better be handled by them.

Two particular lines of activity have been emphasized during the past ten months, namely: —

1. Visits and general surveys of small rural communities in the State, later followed by general reports including specific recommendations for definite projects along the lines of the development of the public tracts within the town.
2. The rendering of further assistance to public institutions in the State, many of the plans and specifications prepared last year having during the past season been followed by construction work.

The work may further be divided as follows: —

1. Answering requests for assistance, including visits, preliminary surveys, preliminary and final reports, lectures, conferences, sketches, detailed plans, estimates and specifications and supervision of construction.

2. Follow-up work whereby the construction is checked and efforts stimulated, revived and redirected in a manner not possible in a strictly professional office.

3. Bringing to as many people as possible throughout the State fundamental ideals and principles of rural town planning by means of illustrated lectures, comparative photographs, leaflets, bulletins, exhibitions of plans, models, demonstrations, and the organization and correlation of existing and proposed agencies within the town looking toward the unification of all efforts.

The department has particularly co-operated with local agricultural instructors, school superintendents and school boards, village improvement societies, town planning boards, boards of trade, town selectmen, women's clubs, churches and other organizations within the community, State Board of Education and the county agents in the various counties.

The fact that the plans prepared as noted above have been followed by definite construction work, by planting and by other phases of development is an encouraging feature in the progress of the work of the past ten months. In the face of the high cost of labor and materials much more of this work has been in progress during the past season than could reasonably have been expected. In some towns so anxious were the residents to see progress that they donated their services gratis to further the project. In other cases local contractors have been willing to co-operate to the extent of performing the labor for cost. (See appended list of towns for which work has been done, with receipts by the Massachusetts Agricultural College and expenditures for construction.)

The list of towns in which construction work has been under way or proposed for this fall and next spring has been appended to this report.

Under the head of "Miscellaneous Activities" should be listed several magazine articles, miscellaneous lectures and conferences in various parts of the State given upon request, courses offered in summer school, exhibitions of plans, and further attention paid during the summer to the preparation of plans for a traveling exhibit to be sent to the libraries of the State.

Summary.

1. Surveys prepared of various public tracts of land in the following towns: Amherst, Chelmsford, East Bridgewater, Littleton, Pepperell, Plainfield, South Deerfield, Templeton.

2. Construction and planting projects proposed and under way in the following towns: Groton, Montague, Littleton, Pigeon Cove, Hubbardston, Templeton, Chelmsford, Pepperell, Westborough, South Ashburnham, Walpole, Groveland, Plainfield.

3. Preliminary plans followed by grading, construction or planting plans prepared for the following towns: Amherst, Chelmsford, East Bridgewater, Hubbardston, Littleton, Montague, Pepperell, South Deerfield, Templeton.

4. Recommendations for town development in the form of construction, grading, planting or otherwise beautifying the streets and public tracts within the town carried out or in process of construction in the following towns: Groton, Groveland, Hubbardston, Montague, Pigeon Cove, Longmeadow, Millis, Pepperell, Plymouth, Red Bridge, South Deerfield.

5. Conferences relative to the Extension Service in rural civic planning in the following towns, with local agricultural instructors, school superintendents, and school boards, village improvement societies and town planning boards, boards of trade, town selectmen, members of the park board, women's clubs, churches and other organizations within the communities, the grange, the State Board of Education, the county agricultural schools, and the county agents in the various counties: Chelmsford, East Bridgewater, Hubbardston, Littleton, Middleborough, Millis, Pepperell, Boston, Belchertown, Groton, Hadley.

6. Lectures delivered by the extension specialist upon town improvement in the following towns: Boxford, Chelmsford, Harvard, Longmeadow, Plymouth, North Attleborough, Red Bridge, South Deerfield.

RECEIPTS FROM TOWNS FOR PLANS AND TRAVEL AND EXPENDITURES FOR CONSTRUCTION, FEBRUARY, 1916, TO NOVEMBER, 1917.

NAME OF TOWN.	Receipts (Plan and Travel).	Expenditures for Construction.
Amherst,	$15 80	-
Bourne,	18 80	-
Boxford,	7 85	-
Chelmsford,	47 46	-
Concord,	17 77	$150 00
East Bridgewater,	74 85	600 00
Grafton,	7 52	50 00
Groton,	41 57	400 00
Groveland,	29 99	50 00
Harvard,	12 45	-
Hathorne,	134 39	-
Hubbardston,	21 68	138 14
Littleton,	47 16	649 75
Longmeadow,	1 10	-
Medfield,	94 72	-
Middleborough,	7 54	-
Millis,	7 04	-
Montague,	51 59	150 00
North Amherst,	-	150 00
Pepperell,	113 59	100 00
Petersham,	38 56	150 00
Pigeon Cove,	125 67	3,000 00
Plainfield,	15 89	3,500 00
Plymouth,	9 68	-
Red Bridge,	4 12	-
Shelburne,	41 72	100 00
Southampton,	4 75	25 00
South Ashburnham,	44 86	1,050 00
South Deerfield,	6 90	-
Sterling,	4 83	-
Templeton,	36 40	100 00
Three Rivers,	50 99	-
Walpole,	195 37	300 00
Westborough,	110 14	250 00
	$1,442 75	$10,912 89

FINAL.

The Extension Service staff have shown a fine spirit of service during this emergency. The acting director desires especially to express his appreciation of the support that has been given the extension work by the Extension Service staff and the various members of the college staff.

FINANCIAL STATEMENT.

REPORT OF THE TREASURER ON EXTENSION SERVICE FUNDS FOR FISCAL YEAR DEC. 1, 1916, TO NOV. 30, 1917.

Disbursements and Receipts.

CLASSIFICATION.	Disbursements.	Receipts.	Apportionment.	Balance.
Administration,	$1,420 55	$63 41	$1,600 00	$242 86
Director's office,	1,646 89	193 10	1,800 00	346 21
Salaries,	31,467 10	-	33,371 66	1,904 56
Correspondence courses,	1,374 53	661 64	400 00	—312 89
Rural civic planning,	732 73	340 91	700 00	308 18
Local community organization,	782 78	-	700 00	—82 78
Home economics,	702 07	-	500 00	—202 07
Co-operation and marketing,	885 24	6 96	800 00	—78 28
County agent work,	461 69	-	200 00	—261 69
Animal husbandry,	476 41	13 56	400 00	—62 85
Junior extension work,	2,383 06	13 02	1,800 00	—570 04
Dairying,	196 92	-	200 00	3 08
Exhibits,	1,136 78	575 00	500 00	—61 78
Lectures,	165 36	36 00	300 00	170 64
Farm management demonstration,	129 69	46 90	100 00	17 21
Pomology,	487 54	87 49	500 00	99 95
Poultry husbandry,	465 52	179 73	300 00	14 21
Library extension,	165 55	-	200 00	34 45
Printing,	2,868 70	1,535 50	1,300 00	—33 20
War emergency,	6,603 91	38 48	-	—6,565 43
Short courses,	12,194 22	3,538 68	9,680 00	1,024 46
Reserve and emergency,	-	-	6,578 23	-
State treasurer,	-	50,000 00	-	-
Totals,	$66,747 24	$57,330 38	$61,929 89	-
Balance beginning fiscal year, Dec. 1, 1916,	-	12,039 70	-	-
Balance on hand Nov. 30, 1917,	2,622 84	-	-	-
Totals,	$69,370 08	$69,370 08	-	-

Summary.

	Disbursements.	Receipts.
Balance Dec. 1, 1916,	–	$13,634 73[1]
Receipts Nov. 30, 1917,	–	7,330 38
Received from State Treasurer,	–	50,000 00
Received from United States Treasurer,	–	16,594 18
Disbursements to Nov. 30, 1917,	$81,952 97[1]	–
	$81,952 97	$87,559 29
Bills receivable Dec. 1, 1916, deducted,	–	622 12
Bills payable Dec. 1, 1916, deducted,	116 87	–
	$81,836 10	$86,937 17
Bills receivable Nov. 30, 1917,	–	776 12
Bills payable Nov. 30, 1917,	139 72	–
Balance,	5,737 47	–
	$87,713 29	$87,713 29

[1] Includes Federal Smith-Lever fund.

Report on Smith-Lever Funds July 1, 1916, to June 30, 1917.

	SMITH-LEVER FUNDS.		
	Total.	Federal.	State.
Dr.			
To receipts from the Treasurer of the United States and from State sources as per appropriations for fiscal year ended June 30, 1917, under act of Congress approved May 8, 1914 (Smith-Lever act).	$20,746 08	$15,373 04	$5,373 04
Cr.			
By salaries,	$14,324 27	$9,730 37	$4,593 90
Labor,	56 53	56 53	–
Printing and distribution of publications,	767 78	767 78	–
Stationery and small printing,	68 92	68 92	–
Postage, telegraph, telephone, freight and express,	180 47	160 56	19 91
Heat, light, water and power,	15	15	–
Supplies,	82 65	77 35	5 30
Library,	–	–	–
Tools, machinery and appliances,	5 62	5 62	–
Furniture and fixtures,	1 75	1 75	–
Scientific apparatus and specimens,	–	–	–
Live stock,	–	–	–
Traveling expenses,	5,257 94	4,504 01	753 93
Contingent expenses,	–	–	–
Totals,	$20,746 08	$15,373 04	$5,373 04

SUMMARY OF STATISTICS OF EXTENSION WORK FOR THE YEAR.

	Number.	People reached.
Extension Service staff: —		
Specialists at college,	25	–
Heads of departments (part time),	8	–
Clerical staff,	16	–
County agricultural agents,	13	–
District market gardening agent,	1	–
County home demonstration agents,	12	–
County club leaders,	6	–
Urban home demonstration agents,	14	–
Correspondence statistics: —		
Single letters written,	28,391	–
Form letters written,	100,095	–
Bulletins mailed singly,	31,839	–
Number of correspondence courses given,	14	733
Present enrollment,	–	530
Publications: —		
Number issued,	54	–
Number of pages,	198	–
Total number of copies,	893,000	–
Miscellaneous printing (announcements, certificates, cards, letterheads, charts, etc.),	335,000	–
News letters,	91	–
Special news letters,	15	–
Number of libraries to which books have been loaned,	56	–
Number of books loaned,	820	–
Number of bulletins loaned,	170	–
Lectures given by extension staff,	640	182,497
Conferences held by extension staff,	943	5,788
Visits made by extension staff,	1,843	–
Demonstrations given by extension staff,	214	18,299
Lectures given by college and station staffs,	257	38,508
Exhibits at agricultural fairs,	8	–
Stock judging contests,	14	–
Number of contestants,	–	200
Poultry shows judged,	6	–
Milk shows,	4	–
Quarterly scoring contest — milk, cream, butter,	3	–
Exhibits loaned — food value of milk and butter making,	5	–
Extension schools: —		
Schools of agriculture and home economics (five-day),	8	–
Schools of home economics (five-day),	1	–
Attendance at agricultural schools,	–	378
Attendance at home economics schools,	–	500
Beekeepers' school (five-day),	1	50
Food conservation schools (one-day and two-day),	85	1,021
Home economics course at Mt. Holyoke College,	1	240
Home economics course at Smith College,	1	27
Home economics study classes (urban),	2	–
Number of boys' and girls' clubs,	8	–
Total enrollment,	–	99,649
Junior judging teams trained,	2	–
Exhibits and fairs attended by junior extension workers,	109	–
Counties working under a community organization project,	11	–
County conferences,	3	–
County councils continued from last year,	1	–
County councils organized this year,	5	–
Communities continuing community work from last year,	35	–
Communities beginning community work this year,	11	–

Summary of Statistics of Extension Work for the Year — Concluded.

	Number.	People reached.
Towns for which construction and planting projects have been prepared,	13	-
Co-operative organizations formed,	12	-
Rural school lunches organized,	16	-
Demonstration orchards under supervision,	14	-
Canning schools at college,	3	83
Conference on local community organization,	1	200
Poultry convention,	1	500
Farmers' week: —		
Number of lectures,	140	800
Departmental educational exhibits,	4	-
Polish Farmers' Day: —		
Number of lectures,	12	300